RTICAL 0.910
le No. 0.631

TWENTY-SECOND ANNUAL REPORT 1948

CENTRAL STATES
FOREST EXPERIMENT STATION
Columbus 13, Ohio
Harold L. Mitchell, Director

MISCELLANEOUS RELEASE NO. 5

JULY 1949

CONTENTS

	Page
Introduction	1
Forest Management	3
Regeneration	3
Spoil Banks Reclamation	5
Silviculture	7
Mensuration	8
Forest Economics	12
Forest Survey	12
Marketing Farm Woodland Products	16
Regional Economic Studies	18
Forest Utilization Service	21
Flood Control Surveys	25
Branch Stations	31
Ames Research Center	31
Buckeye Research Center	36
Carbondale Research Center	39
Northern Ozark Research Center	47
Cooperative Farm Forestry Research	52
Ohio Project	52
Iowa Project	52
Illinois Project	52
Missouri Project	52
Personnel	54
Publications	56

TWENTY-SECOND ANNUAL REPORT

CENTRAL STATES FOREST EXPERIMENT STATION

1948

INTRODUCTION

During 1948 this Station added a Flood Control Survey unit to its Columbus office. The Economics Division was expanded by the addition of a Farm Woodland Marketing project. Two new branch stations were established, one with headquarters at Athens, Ohio, and one at Columbia, Missouri. A new cooperative Farm Forestry Research project was also started in Missouri.

The Flood Control Survey unit is engaged in the Nation-wide flood control surveys being conducted by the Department of Agriculture. The purpose of these surveys is to develop and appraise the effectiveness of remedial programs for reducing flood flows and sedimentation in order to alleviate flood damages. These surveys are conducted jointly by the U. S. Forest Service and the Soil Conservation Service. The Forest Service is responsible for developing a remedial program on forest lands, and the Soil Conservation Service on open lands.

Farm Woodland Marketing research was undertaken April 1, 1948. The broad objectives of this work are to determine the best methods of processing, handling, transporting, and marketing farm forest products. The first marketing research work is being centered in the Missouri Ozarks. This study should develop a technique for securing data to compare the effectiveness of various marketing and processing methods. It will show the current farm woodland marketing practices in this portion of Missouri, and the final report on it will include a directory of local forest industries that buy logs, bolts, and other forest products.

The research center established at Athens, Ohio, is known as the Buckeye Research Center. This unit will conduct a program of research in the fields of timber management, forestation and forest influences. Timber management research will stress silviculture and the costs and returns of various systems of sustained-yield management. Forestation research will be directed toward the development of more efficient methods and equipment for planting spoil banks, submarginal agricultural lands and other areas best suited to forestry. The objective of research in forest influences will be to obtain better information on the effect of various forest types and conditions on the movement and retention of precipitation and on the development and stabilization of soils.

The Northern Ozark Research Center at Columbia, Missouri, was established to help solve the forest, range, and water conservation problems in the Missouri Ozarks and surrounding areas, including eastern Kansas and northeastern Oklahoma.

The general objective of the Missouri Cooperative Farm Forestry Research project is to determine, through a survey of existing plantations, the extent to which the survival and early growth of planted trees of various species are affected by site factors, kind and condition of planting stock, planting methods, and plantation care. This study should provide the information necessary to prepare a planting guide for use in plantation establishment in Missouri.

A detailed discussion of progress on Station projects during 1948, research results obtained, and plans for 1949 is presented on the following pages. This presentation is organized by technical divisions of the Station, with a separate treatment for each research center and cooperative forestry project.

FOREST MANAGEMENT

During the year the forest management staff was chiefly concerned with (1) the management phases of research programs at the research centers, particularly in coordinating and organizing field programs and in reviewing work plans and manuscripts, (2) the region-wide studies to determine forestation possibilities on lands stripped for coal, and (3) certain field experiments initiated prior to the establishment of research centers, and which are best handled by staff men working out of the central office.

Progress during the year, exclusive of that reported by the research centers, and plans for 1949 are described under the following headings: (1) regeneration, (2) spoil bank reclamation, (3) silviculture, and (4) mensuration.

REGENERATION

Progress and accomplishments in 1948

In 1940 yellow-poplar, black cherry, green ash, and red and white oaks were planted in Illinois and Ohio on old fields and beneath an overstory of sassafras, planted black locust, and planted pine. The purpose of the study was to determine the effect of these different nurse covers on the establishment, survival, and growth of some of our most valuable native hardwoods. Within two years of the planting date the crown canopies of the black locust and pine were closed, but the open sassafras stand did not provide a complete crown cover.

In 1948 the plantings were examined and seedling heights were measured. There is little correlation between survival and cover type (fig. 1). The only cover that seems to have had any favorable effect on survival is the pine, and even in this case planted yellow-poplar had a very low (5 percent) survival. Before the summer drought in 1947, yellow-poplar's survival beneath the pine overstory was 68 percent. Apparently the drought did not greatly reduce the survival rate of the other species. Since yellow-poplar is known to require more soil moisture than the other species studied, it is believed that the better survivals for the other species are primarily due to the absence of competing ground cover under the pine. Of the three covers, black locust has perhaps shown the poorest over-all survival of species planted beneath it. This poor survival is unquestionably the result of early overtopping of the planted seedlings by the succulent vegetation that is abundant beneath most black locust stands.

The height growth of all species studied appears to be greatest when planted under black locust (fig. 2). This stimulating effect results from the nitrogen made available by the locust, and appears to be in proportion to the nitrogen requirements of the planted species and to their capacities to respond. Apparently yellow-poplar and black

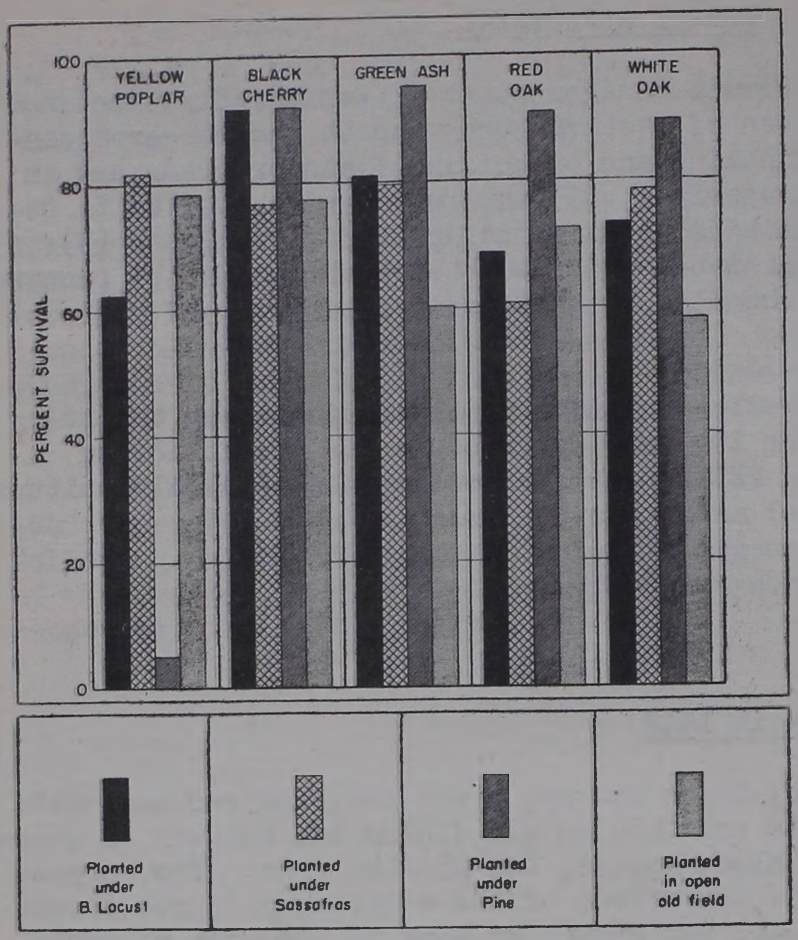


Figure 1.--Survival of five hardwood species planted in 1940 beneath black locust, sassafras, and pine overstories, and on old fields.

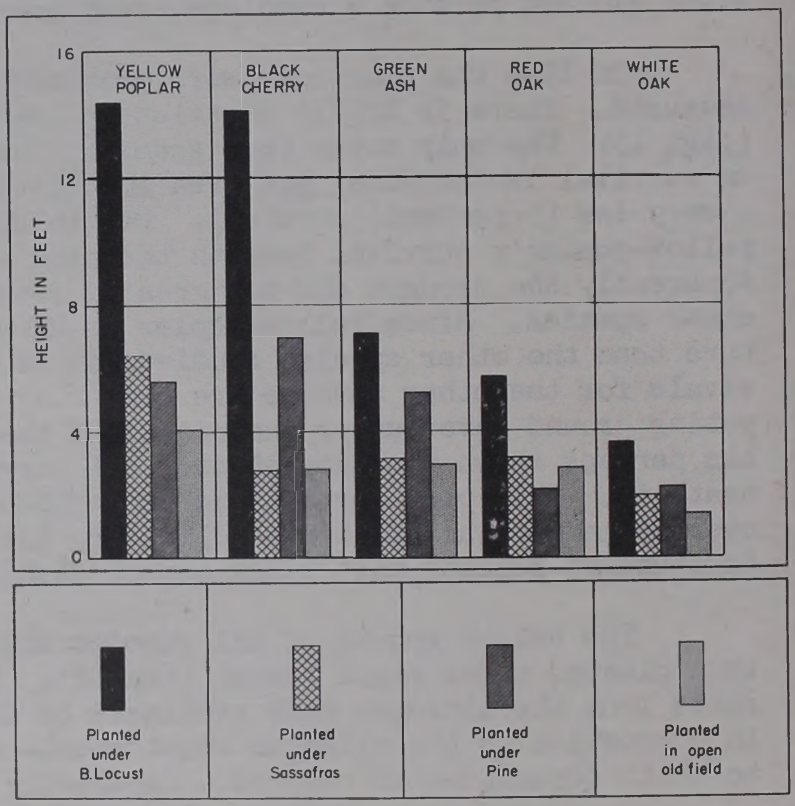


Figure 2.--Heights of five hardwood species planted in 1940 beneath black locust, sassafras, and pine overstories, and on old fields.

cherry respond much better than the other planted species. The other covers do not seem to be consistent in the manner in which they affect the height growth of the species planted in this study. Black locust is therefore highly recommended as a cover beneath which to plant hardwoods, and as a species to use in mixed plantings. For best success only hardwood species that occur or have occurred on a specific planting site should be used in mixtures on such sites.

Plans for 1949

The results of this study will be published during 1949.

SPOIL BANKS RECLAMATION

A technical paper was published entitled, The Extent, Character, and Forestation Possibilities of Land Stripped for Coal in the Central States. It includes a classification of spoil banks for use in forest planting operations and a tentative planting guide to aid in the selection of species for planting. Another paper, The Growth and Development of Black Walnut in Certain Coal Strip-Mined Lands in Southeast Kansas, was presented at a meeting of the Kansas Academy of Science and accepted for publication in the Kansas Journal of Science.

Strip-mine reconnaissance maps were prepared for all the counties located in the coal-mining region of Indiana, and for most of the counties in southeastern Ohio. These maps, drawn to a scale of one inch to one mile, show the location of spoil banks and their classification for planting. Outcrops of the principal coal seams stripped are also shown on some of these maps.

Experimental planting plots were established on a strip-mined area in western Kentucky. This test is designed to study adaptation of species to site and to determine the value of mixed plantings of hardwoods with black locust. Species used in this planting include yellow-poplar, baldcypress, sycamore, black locust, black walnut, sugar maple, red oak, white oak, loblolly pine, pitch pine, shortleaf pine, and Virginia pine. Experimental plantings were also established on stripped lands in Kansas, Missouri, Ohio, and Oklahoma using sycamore, bur oak, and white oak.

In the fall of 1948 a thorough examination was made of experimental plots that had been established in Illinois and Indiana in 1947. Analyses of these data, together with information collected in the reconnaissance of stripped lands in these states, will serve as the basis for a technical paper on reclamation possibilities of spoil banks that will be prepared in 1949. A progress report summarizing the results of experimental plantings on spoil banks in Ohio was issued in 1948. Plots established in 1946 and 1947 continue to show effects of leveling spoil banks on the growth of forest plantations. The growth of black locust,

a fast-growing species, serves as a good index of the relative growth on leveled and unleveled banks (table 1).

Table 1.--Average height of black locust seedlings planted on leveled and unleveled spoil banks in the Central States

Plot location	Site description of plot	Age of plantation	Average seedling height	
			On leveled banks	On unleveled banks
		Years	Feet	Feet
Near Pittsburg, Kansas	Mixture of clay, silty shales, loamy material, and limestone	2	3.5	6.0
Near Cadiz, Ohio	Clay and limestone	3	9.0	10.6
Near Lisbon, Ohio	Silty shales, loamy material, coarse sandstone	3	9.4	9.9

Similar trends have also been observed for such slower-growing species as yellow-poplar, white oak, and white pine, but the differences are still too small to be of statistical significance.

During the 1948 growing season a systematic sampling of moisture conditions on leveled and unleveled plots was made at intervals of from one to three days. Moisture conditions were determined at more than 70 sampling stations selected at random on each of three experimental areas. During the season, therefore, more than 2,000 moisture determinations were made on each of the three areas. A preliminary analysis of these data for the area near Cadiz, Ohio, indicates much drier conditions on the leveled banks in this area than on those not leveled (fig. 3). The vertical scale of figure 3 shows the percentage of the soil samples taken on any observation date that were classified as being very dry (below the wilting range for vegetation). During very wet periods, of course, none of the soil samples fell into the very dry class.

Plans for 1949

Reports will be published on the rehabilitation possibilities of strip-mined lands in most of the states in the region. These will include summaries of reconnaissance data, classification of spoil banks

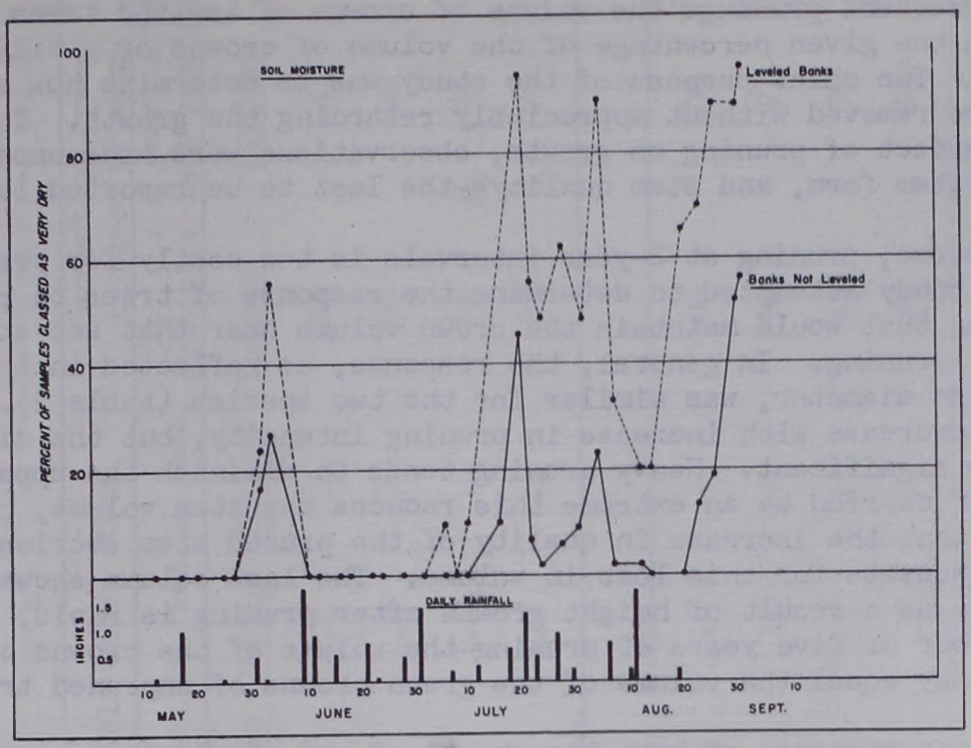


Figure 3.--Comparative soil moisture conditions on leveled and unleveled spoil banks on plots near Cadiz, Ohio. Basis: 70 to 80 samples at 6- to 12-inch depths, at intervals of two to four days from May 12 to September 1, 1948.

for planting, and an analysis of planting results to date. Papers dealing with the effects of leveling on growth of forest plantations will also be prepared.

The existing planting plots will be remeasured and reexamined. New findings of importance will be released as progress reports or technical papers. In addition, a new series of experiments on spoil banks is contemplated. It will include studies of the possibility of coppice management of black locust, of commercial thinning practices for pine plantations, and of marketing black locust and cottonwood.

SILVICULTURE

Progress and accomplishments in 1948

Plantings of shortleaf and pitch pines made in 1936 were first pruned in 1939 and at two-year intervals thereafter. Four degress of pruning were employed: no pruning, light, medium, and heavy pruning. These prunings removed approximately 0 percent, 10 percent, 35 percent, and 75 percent of the crown volume. The first pruning removed approximately the indicated percentage of the volume of tree crown. This was

determined ocularly by comparing the crown profile before and after pruning. In subsequent prunings the volume of crowns of treated trees was kept at about the given percentage of the volume of crowns of similar unpruned trees. The chief purpose of the study was to determine how much crown could be removed without appreciably retarding the growth. To determine the effect of pruning on growth, observations were made upon tree height, stem form, and stem quality--the last to be reported later.

Of course, pruning at 2-year intervals is too costly for practical use, but the study attempted to determine the response of trees to repeated pruning that would maintain the crown volume near that set at the date of first pruning. In general, the response, as reflected in total height and stem diameter, was similar for the two species (table 2). Tree heights decrease with increase in pruning intensity, but the differences are not significant. Heavy pruning tends to diminish the upper-stem diameters. If carried to an extreme this reduces the stem volume, but it seems likely that the increase in quality of the pruned stem section will more than compensate for this loss in volume. The last column shows that crown recovery as a result of height growth after pruning is rapid, and that within four or five years of pruning the volume of the crowns of pruned trees may equal the volume of the green crowns of unpruned trees.

From the response of both the shortleaf and pitch pines, one can deduce that selected crop trees can be pruned to a height of 17 feet (to give a 16-foot log) as soon as the trees have reached the minimum height that will permit leaving as little as 25 percent of the living crown volume. It is doubtful if a one-pruning job would produce the differences in height and diameter that are shown in table 2 for trees repeatedly pruned at 2-year intervals.

Plans for 1949

A manuscript covering the results of this study should be ready for publication before the end of 1949.

MENSURATION

Progress and accomplishments in 1948

Station Note No. 47, Log Rule Comparison, International 1/4-inch, Doyle, and Scribner, was published at the request of foresters in Illinois. The different log-scale volumes were compared graphically for 16-foot logs, and tabularly by diameter classes and by 2-foot log lengths from 8 to 16 feet. Examples were presented to show procedures for converting log volumes and values in terms of one rule to another. The Note was prepared as a handy pocket-size folder in cooperation with the Carbondale Research Center.

Table 2.--Height and upper stem diameter of planted pitch and shortleaf pine receiving four intensities of pruning

Pruning intensity	Basis trees treated	Mean total height	D.O.B.[1] at 4-foot intervals above stump						Percent of green unpruned crowns[2]	
			4 feet	8 feet	12 feet	16 feet	20 feet	24 feet	At pruning	2 years after last pruning
	Number	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Percent	Percent
PITCH PINE										
None	96	25.8	4.8	4.1	3.5	3.0	2.1	1.1	100	100
Light	94	25,6	4.7	4.1	3.5	2.8	1.7	.7	90	96
Medium	88	25.0	4.0	3.7	3.2	2.5	1.6	.4	65	88
Heavy	96	24.2	3.8	3.4	2.9	2.3	1.5	.4	25	75
SHORTLEAF PINE										
None	102	23.9	4.8	4.2	3.2	2.1	.8	-	100	100
Light	102	24.1	4.7	4.2	3.1	2.0	.7	-	90	97
Medium	100	23.8	4.5	3.7	3.1	1.9	.7	-	65	90
Heavy	102	23.2	4.2	3.6	3.0	1.8	.7	-	25	65

1/ Diameter outside bark 4, 8, 12, 16, 20, and 24 feet above stump; basis: one sample tree selected as the mean for each of the four treatments for each species.

2/ The percentages in the two columns "At pruning" and "Two years after last pruning" are based upon a comparison of the volume of crowns of pruned trees with the volume of the green crowns of similar unpruned trees.

The Illinois volume study, initiated late in 1947, was completed in 1948, except for preparation of the final publication. The primary purpose of this cooperative study was to determine if the Lake States Cumulative Tally Sheets were applicable to Illinois timber, and if not what correction factor should be used. Basic measurements for the study were obtained by the following cooperators:

	No. of trees
Illinois Technical Foresters' Association, felled trees..	606
Forest Survey Unit, Central States Station, standing trees measured with a pole caliper.....	565
Carbondale Research Center, Kaskaskia growth plot data (form class, and merchantable length only, standing trees).....	886
Shawnee National Forest, felled tulip-poplar trees.....	37
Old tree measurement data, Central States Station, felled trees.....	232
Total	2,326

Actual tree volumes were compared with volumes read from the Lake States Cumulative Volume Sheets and the following corrections were found to be necessary:

Corrections to be applied to the cumulative tally volume

Species	International & Scribner log rules	Doyle log rules
Maple, Red gum, Post oak, Bur oak	None	None
Ash	Add 3 percent	Add 4 percent
Elm	" 5 "	" 8 "
Hickory	" 6 "	" 8 "
Scarlet oak	" 6 "	" 8 "
Black oak	" 7 "	" 12 "
White oak	" 8 "	" 13 "
Red oak	" 10 "	" 16 "
Yellow-poplar	" 13 "	" 13 "
Hackberry	" 13 "	" 13 "
Beech, Pin oak, Overcup oak, Shingle oak, Boxelder, Black gum, Pecan, Locust	Add 15 percent	Add 18 percent

Corrections to be applied to the cumulative tally volume (Con'td.)

Species	International & Scribner log rules	Doyle log rules
Sycamore	Subtract 7 percent	Subtract 5 percent
Cottonwood	" 3 "	" 0 "
Black walnut	" 10 "	" 10 "
Willow) Blackjack oak)	" 20 "	" 20 "

Plans for 1949

Results of the Illinois volume study will be published. A test of the Mesavage cubic-foot form-class tables will be made and, if needed, correction factors or special tables prepared for Illinois. Other mensuration problems at the Station and research centers will be considered as they develop.

FOREST ECONOMICS

FOREST SURVEY

Progress and accomplishments in 1948

Missouri.--Field work on the inventory phase of the Forest Survey in Missouri was completed late in 1947. During 1948 computations of forest area and timber volumes were completed for each of the Survey regions in the state. Releases were published showing these area and volume data for the following regions:

Eastern Ozark region
Southwestern Ozark region
Northwestern Ozark region
Prairie region
Riverborder region

A sixth release summarizing these data for the state was also published.

Analysis of growth data from increment borings was also completed during the year, and growth computations were made for the principal species groups. Board-foot and cubic-foot growth estimates for the entire state were nearing completion at the end of the year.

The first draft of the comprehensive report on the forest situation in Missouri was approximately 90 percent completed during 1948. This report analyzes the forest statistics for the state, shows the present and potential importance of the forests to the people of Missouri, and suggests measures that can increase the contribution of the forests to the economy of the state. Preliminary plans have been made to have this report published by the Agricultural Experiment Station of the University of Missouri. It will point out that of the 15.2 million acres of forest land in the state, 10.2 million acres or more than 65 percent is in the Ozark regions (table 3). In the Prairie region of the western and northern portions of the state, forests occupy only 13 percent of the land area. The total volume of timber in trees of saw-timber size is nearly 12 billion board feet (table 4). The Ozark regions contain 6.4 billion feet, but the average volume per acre in the Ozarks is much lower than in other portions of the state. The total cubic-foot volume in sound trees 5.0 inches d.b.h. and larger is 4.4 billion cubic feet.

Illinois.--The field work of the inventory phase of the Forest Survey started in Illinois in August 1947 and was completed in May 1948. A total of 191,350 systematically selected 1-acre plots on aerial photographs covering the state was examined to obtain estimates of forest area by counties. Approximately 5,930 forest plots were stereoscopically examined on the photographs and were classified as saw timber, pole timber, seedlings and saplings, or poorly stocked. This classification provided the basis for selecting plots for field examination. A total of 1,033 forest plots was examined on the ground to obtain information on tree species, tree size, and on the volume, condition, and growth of

timber stands. In addition, 266 plots classified as nonforest by the photo interpreters were field-checked to obtain data on the rate of reforesting of open land.

Table 3.--Total land area, total forest area, and commercial forest area in Missouri by regions, 1947

Region	Total land area	Forest area		Commercial forest area
	Thousand acres	Thousand acres	Percent	Thousand acres
Eastern Ozark	6,174	4,488	73	4,433
Southwestern Ozark	5,531	3,130	57	3,111
Northwestern Ozark	5,059	2,603	51	2,579
Prairie	19,557	2,496	13	2,490
Riverborder	8,012	2,470	31	2,461
All regions	44,333	15,187	34	15,074

Table 4.--Board-foot and cubic-foot timber volume in Missouri by regions, 1947

Region	Saw-timber volume		Cubic volume	
	Total	Average per acre	Total	Average per acre
	Million bd.ft.	Bd. ft.	Million cu.ft.	Cu. ft.
Eastern Ozark	3,062	691	1,266	286
Southwestern Ozark	1,976	635	705	227
Northwestern Ozark	1,358	527	551	214
Prairie	2,675	1,074	876	352
Riverborder	2,827	1,149	960	390
All regions	11,898	789	4,358	289

With the cooperation of the Illinois Agricultural Experiment Station, University of Illinois, and of the Division of Forestry, Illinois Department of Conservation, the sampling intensity of the Survey was

increased in the southern 16 counties in the state to provide more detailed information on the forests of this region. In these counties estimates of volume may be sufficiently accurate to permit release by individual counties or pairs of counties.

The determination of the 1947 cutting drain on the forests of Illinois was a cooperative project in which several agencies participated. Data on lumber production were obtained for each county by the Bureau of the Census as part of the Census of Manufacturers. The Bureau of the Census also collected information on the volume of wood used in the production of veneer and cooperage stock. Information on the production of fuelwood, fence posts, mine timbers, and other products was obtained by the foresters of the Division of Forestry, Illinois Conservation Department, and of the Illinois Agricultural Experiment Station, University of Illinois. The Forest Survey staff developed the sampling procedure used in this study and also directed the work. Computation of the data was also a responsibility of the Survey. At the end of the year, all drain field work had been completed except that necessary to obtain information on the source of the cooperage and veneer production reported by the Bureau of the Census.

By the end of the year computation of forest area and timber volume data for Illinois was nearing completion. All plot data had been transferred to punch cards and most of the machine tabulations had been made. Computation of drain data was approximately half completed. No work was done on Illinois growth computations during the year.

The tabulation below shows the land area statistics for Illinois:

Total land area	35,806,000 acres
Total forest area	3,996,000 acres
Percent forest	11.2 percent
Commercial forest area	3,941,000 acres

The distribution of the forest area among the stand-size classes is:

	Thousand acres	Percent
Saw-timber areas	1,824	46.3
Pole-timber areas	983	24.9
Seedling and sapling areas	729	18.5
Poorly stocked areas	405	10.3
All areas	3,941	100.0

The following tabulation shows the total volume of saw timber in the state to be 10.3 billion board feet. The average volume per acre is 2,625 board feet. This is more than three times the average volume per acre in Missouri.

	Total volume million bd. ft.	Average volume per acre bd. ft.
Saw-timber areas	9,125	5,003
Pole-timber areas	738	751
Seedling and sapling	204	280
Poorly stocked areas	279	689
All areas	10,346	2,625

Kentucky.--The Forest Survey of Kentucky began in March 1948, when the photo interpreters began the study of aerial photographs of the counties in the western part of the state. Field inventory work began in May. After field work had been completed in a number of the western counties, the Forestry Relations Division of the Tennessee Valley Authority proposed a cooperative program for intensifying the work in the 11 western counties. As a result of this proposal, a plan was developed and carried through by which the number of field plots taken in these counties was doubled. Eight foresters from the TVA and one each from the Kentucky Forest Service and the Kentucky Extension Service were trained by Forest Survey Staff members and spent two months taking the additional field data. This intensification will result in more accurate forest area and volume data for the 11-county unit.

By the end of the year, field inventory work had been completed for approximately one-third of the state.

Plans for 1949

The comprehensive report on the forest resources of Missouri will be completed early in the year. After review and revision it will be submitted for publication.

A state statistical report for Illinois will be issued early in the year giving forest-area and timber-volume information for each of the three Survey units and for the state as a whole. Field checking of Illinois drain data and computation of drain information will be completed. Growth computations will be started as soon as area and volume tabulations are completed. The first draft of the analytical report for Illinois will be prepared.

In Kentucky major emphasis will be given to completing the inventory work and in making a drain survey of the state. At the present rate of progress the inventory plot work should be completed by November. The drain survey will be made on a sampling basis to obtain the volume of wood cut during 1948. Lumber production will be obtained by making a mill canvass of all sawmills in selected counties and using this sample to adjust the 1947 production figures of the Bureau of the Census to give the 1948 production. The production of fuelwood and fence posts will be determined by interviewing all farmers and wood producers on a number

of areas randomly selected from the Master Sample of Agriculture. Mine-timber production will be estimated by obtaining from representative mines data on the volume of wood used per ton of coal mined and by applying this factor to mine production figures for the state. Information on other wood-using industries will be obtained by sampling or by interviewing all operators.

Statistical reports will be published giving forest area and timber volume data for at least one of the western Kentucky Survey Units.

Present plans call for extending the Forest Survey to Ohio late in 1949, after completion of the work in Kentucky. There is a good possibility, however, that a considerable portion of Ohio may be rephotographed during 1949. If so, the Survey program for Ohio may be postponed so that advantage can be taken of new photography. If this is done, the Survey will cover Iowa or Indiana before starting in Ohio.

MARKETING FARM WOODLAND PRODUCTS

Farm woodland marketing work was started at this Station in April 1948, under authority of the Research and Marketing Act of 1946. The broad objectives of this work are to determine the best methods or processing, handling, transporting, and marketing farm forest products, and to make public the results of these investigations for the purpose of improving the marketing practices used in selling farm woodland products.

Progress and accomplishments in 1948

This program was initiated by visiting leaders in state forestry, farm forestry, extension forestry, and county agents throughout the Station territory to discuss the principal local problems in marketing farm-woodland products. A study was also made of all available literature on farm woodlands and woodland product marketing, and of existing information on the number, location, and production of forest industries in the Central States. As a result of this preliminary work, an analysis of the problems of marketing farm woodland products in the Central States was prepared.

This analysis (1) divided the Station territory into major marketing resource districts, describing the woodland resources of each, and the local utilization procedures and marketing practices, (2) indicated the principal woodland marketing problems in each marketing district in the Central States territory, (3) summarized the woodland marketing activities of other agencies, (4) indicated areas and projects suitable for marketing research, and (5) proposed the marketing research that should be undertaken at once.

Facts brought out by the analysis indicated that the first marketing research work should be centered in the Missouri Ozarks. It is a rough hilly area with thin rocky soils. The oak-hickory type predominates and the forests have, in general, been cut over for the better-quality material, grazed, and burned until the average saw-timber volume is less than 650 board feet per acre. About 55 percent of the area is in forest, of which more than half is farm woods. Many of the farms, because of poor soil and a small area of cropland, can only support their owners or operators on a mere subsistence level. As a result, the woodlands, even in their depleted condition, are an important source of farm income.

Furthermore, farm woodland products are not, as a rule, marketed effectively in the Ozarks. In the main, the owners do not know and are indifferent to the best and most profitable ways of marketing their woodland products. They frequently sell the standing timber for a lump sum that may be considerably less than the actual value. Oftentimes a tie buyer or other purchaser of relatively low-quality material buys a woods for his product and puts into a low-quality product material that is suited for a considerably higher-quality use. Small sawmill operators, each cutting less than 500 thousand board feet per year, manufacture more than half of all the lumber produced in this area. They frequently do not pay full value for the stumpage. Sometimes they are actually unable to pay more because of ineffective sawing and marketing practices.

The field work for this study is being done in the northern portion of the Ozarks in Camden, Dent, Maries, Miller, Phelps, and Pulaski Counties. The objectives are:

(1) to develop a technique for securing data to compare the effectiveness of various marketing and processing methods. This technique will be useful to farm extension foresters, county agents, and others who may have occasion to compare various methods of marketing and processing forest products;

(2) to study and report on the current farm woodland marketing practices in the selected counties, and to provide information that can be used to improve the present marketing practices, and

(3) to compile a directory of local forest industries that buy logs, bolts, and other forest products.

Thus far studies have been carried on at several small sawmills and woods operations in the selected area. The sawmill studies are providing information on the comparative costs and returns from making lumber from logs and trees of various diameters and lengths. Man-hour figures as well as costs and returns will be shown in order to emphasize the differences in production rates and to permit the use of results after wage rates and other operational costs have changed considerably.

One study at a commercial circular sawmill with edger indicates that lumber production per hour is 2½ times as great when sawing pine logs averaging 10 inches in diameter as when sawing logs averaging 5 inches in diameter. Cost-and-return information on this same operation indicates that net returns per thousand board feet of lumber are more than twice as great when 10-inch logs are sawed as when 5-inch logs are sawed. Although these results are based on a single operation, they are at least indicative of what can be expected for operations sawing logs from farm woodlands.

Plans for 1949

The individual mill and woods studies and the contacts with wood-using industries in the Missouri study area should be completed in the spring of 1949. At that time one of the two men assigned to the project will begin farm woodland marketing studies in southern Illinois and western Kentucky.

Tentative publication plans for the Missouri data have been made. They include: (1) Station notes for some of the individual mill or industry study results, (2) a Station note listing the wood-using industries of the 6-county area and the specifications for the material they buy, and (3) a technical paper that outlines the technique used in making these studies, reports on the forest products marketing situation in the area, and suggested ways of improving the marketing practices for woodland products.

REGIONAL ECONOMIC STUDIES

Progress and accomplishments in 1948

A study of the problems and costs involved in producing wood chips from coarse fiber, first described in the Annual Report of 1947, was continued during the first six months of 1948. Field work included a thorough survey of the use of wood by the felt mills of the asphalt roofing industry in Illinois, Indiana, and Ohio, together with the collection of information on costs, procedures, and results of different kinds of wood-harvesting and chipping-plant operations. These data provided a basis for estimating future trends of wood procurement in the felt industry and in other industries that can use coarse wood chips as raw material. Although the local wood now used is mostly pole-sized growing stock and its volume is insignificant compared to the volume of waste available, future use of waste wood may be important. A few of the potential products are wallboard, insulating board, corrugating paper, bulk-fiber insulation, wood yeast, and wood molasses. If costs can be reduced and certain other obstacles can be minimized, much wood that is presently unsalable can be put to profitable uses.

Preliminary results of the study are contained in the Case Histories of Feltwood Operations that were duplicated and distributed by the Forest Products Laboratory. Thirteen case histories and two supplements were published in 1947 and 1948. Collection of data was completed in the summer of 1948. The report on the study will be issued as a Station Technical Paper early in 1949 under the title The Costs of Producing Wood Chips for Coarse Fiber in the Central States Region.

During the year the use of wood chips in the manufacture of roofing felt and other felt products continued to expand. At least one new plant came into production, and capacity was increased in others. In 1947, felt mills in the three states used the equivalent of slightly more than 100,000 standard cords of wood. More than one-half of this volume came from cordwood chips of central hardwoods; about one-third came from slabwood and veneer core chips of northern hardwoods; and the remainder came from shredded aspen, ground softwood waste of planing mills, shavings, and sawdust. Consumption in 1948 was probably greater for all items except shredded aspen. In addition certain mills began to use broken blockwood—chiefly western softwoods--from remanufacturing plants, feeding it into the defibrators in the same manner as chips.

In some areas increased consumption strengthened the local market for cordwood. Land clearing and other clear-cuttings supplied the wood for these markets; very little of it came from waste wood of any kind. Wood from partial cuttings and from most slash-removal operations cost more per cord to produce than wood from clear-cuttings, while the manufacturers' aversion to large percentages of bark kept slabwood from being used.

Cutting cordwood, or feltwood, for felt mills is small, local business. Since maximum economic truck-hauling distances for wood are usually no more than 30 miles from woods to chipping plant or felt mill, there is little competition among local marketing areas and no over-all market price. Prices range from $6.50 to $14.00 per standard cord delivered at the chipper.

A large quantity of feltwood is sold on a weight basis--by the ton instead of by the cord. Although this procedure, because of the variable moisture content of wood, does not always give a uniform volume of wood per unit of weight, it does have several advantages. Wood can be cut and sold in random lengths. This eliminates cutting to length, careful piling, and scaling of piles. Selling by weight also reduces the time needlessly spent in splitting to small diameters and piling in loose cords. The net result is usually increased production per man-hour.

The cost of chipping roundwood varies from about $1.00 to $1.50 or more per ton, depending upon such factors as degree of mechanization in handling wood, volume of output, and plant efficiency. At the larger sawmills, where wood is handled mechanically, slabwood can ordinarily be chipped for less than $1.00 a ton. Slabwood at Lake States sawmills is chipped for felt making, but chips from central hardwood slabs are not

at present acceptable. A small volume of the latter chips is produced and used in metallurgical plants for making certain alloys.

The study of wood-chip production pointed up some of the factors that govern the buyers' choice of wood. Briefly stated, they are suitability, availability, and cost. If the industries that can use wood chips are to utilize low-quality and waste wood, such wood must be able to compete in the open market or else possess some special advantage. At present, clear-cutting pole stands provides technically superior wood at the lowest cost. High prices for agricultural products have stimulated land clearing, and have made large volumes of this wood available. If crop prices decline and land clearing becomes less common, or if more owners become convinced of the wisdom of holding timber to maturity, pole stumpage may become scarce. Heavy cutting may produce the same result locally. Low-quality and waste wood may then receive greater attention.

Plans for 1949

Except for the publication of the report, no further work on this study is planned for 1949.

FOREST UTILIZATION SERVICE

The threefold function of the Forest Utilization Service at this and other Stations is (1) to keep in close touch with wood utilization problems in all parts of the Station territory, (2) to present to the Forest Products Laboratory or other products research agencies those problems of local forest industries that require new or supplemental research, and (3) to provide industry operators with information on efficient processes, procedures, and equipment developed by forest products research.

Progress and accomplishments in 1948

At the beginning of the year, the two staff members of the Forest Utilization Service covered Indiana, Illinois, Iowa, and Missouri to review local forest utilization problems with such forestry leaders as supervisors of national forests, state foresters, extension foresters, staff members of college forestry departments, and personnel of branch stations of the Central States Forest Experiment Station. The three primary problems appeared to be (1) the high proportion of low-grade lumber produced by small sawmills, (2) the large volume of wood wasted in sawmilling, and (3) the lack of profitable market outlets for low-grade lumber. Two basic remedies suggested for these problems are the establishment of efficient concentration yards with rough-product remanufacturing facilities, and marketing research giving special attention to local utilization of products not now used. The Forestry Department of Iowa State College assigned one research assistant to marketing studies early in 1948. Also, the Division of Forest Economics at this Station has started marketing studies.1/

Consulting and advisory services are becoming the major activities of the FUS men. During 1948 on-the-ground consulting and advisory services were furnished to nearly 200 primary producers, 125 wood-products remanufacturing establishments, and 27 miscellaneous industrial concerns such as woodworking equipment manufacturers, pulp and paper mills, livestock feed companies (wood molasses), and present or potential users of wood or modified wood products. Some 250 additional companies and individuals were given advisory service and special information by correspondence or by referring inquiries to the Forest Products Laboratory or other sources of information.

On October 14 a logging equipment demonstration was held on the Kaskaskia Experimental Forest in southern Illinois. Sponsored jointly by members of the Forest Utilization staff, the Carbondale Branch Station, and the Extension Forester of the University of Illinois, this demonstration attracted approximately 800 loggers and sawmill men, nearly 100 of whom came from adjacent portions of Indiana, Kentucky, Tennessee, and Missouri. This show gave manufacturers an opportunity to

---

1/ See page 16.

demonstrate their products under actual field conditions where skilled operators could display equipment to best advantage. Factory representatives, district managers, and distributors for 30 manufacturers of logging and sawmilling equipment were present. Much of the equipment was new to the Central States.but well adapted to conditions here. A new Junior model log sulky, well-suited to farmwoods operation, attracted considerable attention from the smaller operators. Two new types of self-loading trucks, which are inexpensive and adapted to the long hauls common in the Central States, were demonstrated. Other equipment demonstrated for the first time in the Central States included: the Oliver Corporation's Logging Kit, a tractor attachment for log skidding, the Dowd Hydraulic Log cart, and the latest models of both the Champion and Loggers' Dream loaders. The International TD-9 tractor with Superior crane was of interest to the larger operators. The highly mobile Jackson Lumber Harvester was one of two portable sawmills at the show. This mill holds considerable promise for farmwoods operation in the Central States, particularly in connection with farm cooperatives.

At the conclusion of the demonstration it was suggested that similar shows be held annually and that they rotate among the states in the region. Extension foresters of two states have already approached Station members concerning a show in 1949.

A representative of FUS, together with specialists from the Divisions of Timber Physics and Industrial Investigations of the Forest Products Laboratory, assisted the Iowa Extension Forester in holding a series of sawmill-operator training meetings at six widely separated Iowa locations during the first half of October. Hardwood lumber grading, sawing for grade, air seasoning, and kiln drying were topics presented by FUS and Laboratory personnel. At each meeting the FUS representative demonstrated the use of the SCR-625 Army mine detector for locating metal in logs.

The Forest Products Laboratory, assisted by the local Forest Utilization Service, conducted a gluing clinic in Louisville, Kentucky. The clinic consisted of a week's observations of gluing practices at remanufacturing plants in the Louisville area followed by a 3-day series of lectures and group discussion. The Hardwood Dimension Manufacturers Association cooperated in making local arrangements for the clinic. Some 25 industry men attended on a cooperative-fee basis. This was the first gluing demonstration ever given by the Forest Products Laboratory outside of Madison.

A manufacturer of high-grade book and magazine paper began a study of the possibilities of installing a new pulp mill in this region to use wood waste from remanufacturing plants exclusively. FUS is helping to locate sources of suitable waste supplies in Ohio, Indiana and Kentucky. Hardwood waste only is desired, free of bark, and with no sawdust or other fine material.

Specialists of the FUS and the Forest Products Laboratory advised the Chamber of Commerce, Harrison County, Indiana, regarding possibilities

for increasing local employment by the further remanufacture of wood products. Similar help was given to the forest manager of the Muskingum Watershed Conservancy District in Ohio, who desires to expand local wood harvesting and milling operations and to add wood remanufacturing facilities. The Cooperative Wood Waste Development Association of Ohio has shown particular interest in making hardboard and wood molasses from wood waste and has asked counsel of the FUS men.

Feed companies and animal husbandry departments at agricultural experiment stations in this region were encouraged to carry on livestock feeding experiments using wood-sugar molasses and fodder yeast from wood waste. Except as a pellet-feed binder and a mixed-feeds dust reducer, very little molasses of any kind has been used in this region. The small pilot plant at the Forest Products Laboratory is currently the only source of wood sugar, and its output has been largely obligated in the South and West where feed supplements are important in the livestock economy. However, more feeding experiments with both wood-sugar molasses and yeast are definitely scheduled by feed companies in this region, and several of the animal-husbandry specialists at colleges and experiment stations have signified their willingness to put such tests into their research programs for 1949 and 1950. By then it is expected that additional supplies of wood sugar will be obtainable.

Plans for 1949

The Forest Utilization Service staff will continue to make field contacts throughout the Station territory in an effort to secure more effective wood utilization in the wood-processing industries.

In the primary industry field several specific projects are proposed for 1949. One of these involves a study of the postwar problems confronting the small circular sawmill operator. With the passing of the seller's market, the speculative or fly-by-night operator has largely disappeared. There is, however, a great need for a stabilized small-sawmill industry in this region if continuous and profitable markets for farm timber are to be maintained. It would be unfortunate if the marketing and operational problems of the small year-round custom mill and the seasonal farmer mill forced these types of mill out of production in the Central States. Normally these mills produce more than 80 percent of the lumber sawn in the region. The proposed study will determine the more important problems in this field, and the FUS will try to interest the proper agency to undertake their solution, be they economic, silvicultural, or engineering. The study of problems associated with reestablishing the concentration yard as a market outlet for the lumber of small mills will also be continued. Concentration yards were, for the most part, discontinued in the Central States region during the war, and their reestablishment has been disappointingly slow. The efforts to interest equipment manufacturers in developing light mechanized tools especially designed for farmwoods logging operation will be continued and expanded. Where satisfactory agreements can be worked out, equipment will be tested

or developed on experimental forests. There is increasing need for an experimental area set up primarily for such work. It is probable that a second logging equipment demonstration will be held in October or November. If so, it will probably be a 2-day show, which will provide time for a better balanced program.

Projects in the manufacturing field which will receive special attention during 1949 are (1) better utilization of wood waste, including unmerchantable trees, for making remanufactured items, pulp and paper, hardboard, and wood-sugar products, (2) improvements in seasoning and moisture-control practices to reduce losses, (3) liaison contacts with glued-wood products fabricators further to reduce manufacturing losses in gluing, (4) new uses for modified woods, and (5) liaison contacts to determine possibilities for improving box and crate construction.

FLOOD CONTROL SURVEYS

The Flood Control Survey unit at this Station is engaged in the Nation-wide flood control surveys being conducted by the Department of Agriculture. The purpose of these investigations is to develop and appraise the effectiveness of remedial programs for reducing flood flows and sedimentation in order to alleviate flood damages.

It should be pointed out that the Department of Agriculture's flood-control activities are aimed at controlling water on the land, where it falls, while the Army program is directed at controlling water after it enters the stream channels. Neither program can replace the other; both are needed; both must be closely integrated in any comprehensive flood-control program.

The Department of Agriculture flood control surveys are conducted jointly by the Forest Service and the Soil Conservation Service. The Forest Service has primary responsibility for surveys on watersheds principally forested, while the Soil Conservation Service has the primary responsibility on watersheds where most of the land is in agricultural use. In either case, the Forest Service develops the remedial program on the forested portions of all watersheds, and the Soil Conservation Service is responsible for program development on open land.

Flood control field surveys cover four related yet distinct phases: (1) preliminary examination, (2) survey work outline, (3) detailed survey and report, and (4) survey report review.

Preliminary examination.--When Congress has approved a flood-control survey for a watershed, a preliminary examination is made to determine whether a remedial program for flood control appears to be sufficiently feasible to warrant a detailed survey. The preliminary examination is of a reconnaissance nature in which the data are obtained from a brief field examination of the watershed and from interviews with local people and state and federal land-management agencies. The results of this examination are incorporated in the preliminary examination report. If this report indicates that a remedial program can alleviate the flood situation, a detailed flood-control survey is authorized by the Secretary of Agriculture. An unfavorable preliminary examination report prevents further survey activity in the watershed until Congress reauthorizes another examination.

Survey work outline.--After the preliminary examination, but before the beginning of the detailed survey, a work outline must be formulated. This is a formal agreement or contract between the Soil Conservation Service and the Forest Service. It states the general procedures to be used in making the detailed survey, outlines and schedules the work to be undertaken by each agency, sets up the organization of personnel by grades, and contains an estimate of the cost of the detailed survey.

Detailed survey and report.--The detailed survey, which requires a considerable amount of field work and interviews with local people and state and federal officials, includes the analysis of the flood problem, the development of a remedial program, and a comparison of the benefits and cost of the program. The remedial measures to ensure that the hydrologic condition of the woodland is brought up to a high standard and kept there, usually include fire control, elimination of woodland grazing, forest planting, and technical assistance to woodland owners. As a facilitating measure, public land acquisition is proposed where private owners cannot participate adequately in the proposed remedial program. The cost of the programs is distributed among the local people and the state and federal governments. All federal costs are considered to be flood control costs, while state and private costs are included in other costs.

Flood-control benefits include the reduction of flood-water peaks; reduction in land damages from sedimentation; reduction of sedimentation in reservoirs, stream channels, and other works along streams; enhancement of property values; and off-site benefits from increases in low-water flow. This latter, in turn, increases power capacity, improves water quality, increases the quantity of water available for use, and improves the habitats for fish and other aquatic animals.

Nonflood-control benefits, sometimes referred to as "non-public," "conservation,""incidental," or "on-site" benefits are those benefits that accrue to the land operator as a result of program participation. Such benefits include increased income because of increased crop or timber yields or other advantages. On-site benefits also include increased income from public lands and decreased costs of maintenance of roads and highways at the point of treatment.

Because of the interdependence of the factors affecting run-off, it is impossible to evaluate separately the effects of the individual remedial measures proposed. However, the flood control benefits can be evaluated separately from the on-site benefits, and the flood control costs can be separated from the other costs. This permits developing flood control and over-all benefit-cost ratios, which form the basis for determining whether or not a remedial program is recommended for the watershed. To warrant an action program there is the legal requirement that all benefits must equal all costs; as a matter of Departmental policy, the flood control benefits must equal at least one-half the federal costs.

Survey report review.--The results of the investigations conducted during the detailed survey are incorporated in the flood control survey report. The report, prepared by the responsible agency with the collaboration of the other agency, is reviewed by the various field units within the agencies which prepare the report before it is submitted to Washington.

Progress and accomplishments in 1948

Flood control survey activity at the Station commenced April 1. Work during 1948 was restricted to participation in watershed surveys under the responsibility of the Soil Conservation Service. This participation involved (1) preliminary examinations and reports, (2) survey work outlines, (3) detailed surveys and reports, and (4) the review of reports. The work accomplished for the period April 1-December 31 and the status on December 31 are summarized below:

Status and watershed	Watershed location
Preliminary Examinations Completed	
Missouri	Iowa, Missouri[1/]
Upper Mississippi	Illinois, Indiana, Iowa, Minnesota, Missouri, Wisconsin
Survey Work Outlines Completed	
Galena	Illinois, Wisconsin
Green	Kentucky
Missouri	Iowa, Missouri[1/]
Root	Minnesota
Scioto	Ohio
Upper Mississippi	Illinois, Indiana, Iowa, Minnesota, Missouri, Wisconsin
White (E. Fork)-Patoka	Indiana
Surveys Underway	
Grand	Iowa, Missouri
Sangamon	Illinois
Upper Mississippi	Illinois, Indiana, Iowa, Minnesota, Missouri, Wisconsin
White (E. Fork)-Patoka	Indiana
Surveys Completed	
Galena	Illinois, Wisconsin
Missouri	Iowa, Missouri[1/]
Root	Minnesota
Scioto	Ohio
Reports Reviewed	
Indian Creek	Iowa
Osage	Kansas, Missouri
Root	Minnesota
Whitewater	Minnesota
Reports Under Review	
Galena	Illinois, Wisconsin
Scioto	Ohio

1/ Station activities confined to Station territory only.

The flood control investigations show that the hydrologic condition of forest lands in the Middle West is generally poor (table 5).

Table 5.--Hydrologic condition of woodland by important watersheds in the Central States region, 1948

Watershed	Area of woodland	Hydrologic condition class			
		Good	Medium	Poor	All classes
	Thousand acres	Percent	Percent	Percent	Percent
Galena	8	0	8	92	100
Missouri 1/	3,785	2/	2/	100	100
Root	162	2/	1	99	100
Scioto	828	0	6	94	100
Average	-	2/	1	99	100

1/ Iowa and Missouri portions only (Missouri portion does not include the Gasconade tributary watershed).
2/ Less than 1 percent.

The principal factors causing this situation are grazing, burning, overcutting, and improper logging. By applying the remedial measures listed on page 26, the hydrologic condition of these lands can be improved considerably. The extent and cost of the measures proposed in reports on the completed surveys are shown in table 6. Since the effects of individual measures on flood run-off cannot be determined, the flood-control benefit of these programs is not available for the woodland and open lands separately. Nevertheless, as shown in column 1 of table 7, the flood-control benefit of the combined measures on all lands in each watershed surveyed exceeds the federal cost.

The Station also participated in developing the Departmental program for the Missouri River Basin. The Station was represented at the Denver Conference held in September, and our flood control unit assumed leadership in drafting the forest research plans for the Station territory lying within the Basin. Staff members also served as consultants to regional specialists drafting the action program for the forest lands in the watershed.

Table 6.--Extent and cost of woodland measures proposed in remedial programs of completed flood control surveys[1/]

Measure	Galena			Missouri[2/]			Root			Scioto		
	Area affected	Cost		Area affected	Cost		Area affected	Cost		Area affected	Cost	
		Establishment	Annual maintenance		Establishment	Annual maintenance		Establishment	Annual maintenance		Establishment	Annual maintenance
	Thousand acres	Thousand dollars	Thousand dollars	Thousand acres	Thousand dollars	Thousand dollars	Thousand acres	Thousand dollars	Thousand dollars	Thousand acres	Thousand dollars	Thousand dollars
Fire control	0	0	0	4,004	7,428	403	212	25	2	564	191	11
Grazing control	19	3/	3/	4,435	3/	3/	212	3/	3/	732	3/	3/
Forest planting[4/]	11	227	0	549	10,213	0	21	526	0	42	749	0
Technical assistance	19	41	3	4,435	28,103	938	212	457	34	732	1,693	179
Land acquisition[5/]	0	0	0	685	2,950	0	0	0	0	30	450	0
Mountain channel stabilization	0	0	0	-	250	0	0	0	0	0	0	0
Testing of measures	-	10	2	-	155	40	-	0	0	-	20	5
All measures	-	278	5	-	49,099	1,381	-	1,008	36	-	3,103	195

1/ Includes federal, state, and private contributions for 100 percent participation. Recommendations include new measures or intensification of old measures beyond what is now being done in the watershed.

2/ Only for the Iowa and Missouri portion exclusive of the Gasconade tributary watershed.

3/ As the Soil Conservation Service considers grazing control to be an open-land measure, the fencing costs are included in pasture costs, which are not shown here.

4/ Includes complete planting, spot planting, and site examinations required before planting.

5/ Includes cost of land and administrative cost of acquisition. Acquisition is all national forest except for 675,000 acres set up for state forests in the Osage River tributary watershed of the Missouri River Basin.

Table 7.--Estimated benefit-cost ratios to be obtained under the flood control programs

Watershed	Benefit-cost ratio	
	Flood control 1/	Over-all 2/
Galena	1.7	3.6
Missouri 3/	1.2	2.6
Root	1.3	3.2
Scioto	1.6	3.9

1/ Reduction in flood and sedimentation damages divided by federal costs.
2/ Reduction in flood and sedimentation damages plus increased land-owner income from the program divided by federal, state, and private costs.
3/ Includes entire Missouri River Drainage Basin except the Gasconade tributary watershed.

Plans for 1949

It is expected that the surveys now underway will be completed and that the surveys on the Green and Upper Ohio River watersheds will be undertaken during 1949.

BRANCH STATIONS

AMES BRANCH

Progress and accomplishments in 1948

Most of the efforts of the staff went into plans for and the operation of the Paint Creek Experimental Forest. This is a cooperative undertaking; the forest and funds for operating it are furnished by the Iowa Conservation Commission, and the research program is developed and directed by the Ames Research Center. Harvesting and sawmilling operations were started on the Paint Creek Experimental Forest during 1948. In addition, a planting study and various other investigations were initiated. The major "housekeeping chores" that were completed include the setting of a circular sawmill on concrete footings, the constructing of a protecting shed, and the building of roads and boundary fences.

Improvement Cut at Paint Creek

During the year an improvement cut was made on approximately 80 acres of the Paint Creek Experimental Forest. The objective of this cut, which will later be extended to the remainder of the experimental forest, is to put the stand in condition for management research by removing cull and low-quality trees. The initial cutting yielded much information on growth, cull, extent of defect, and other factors that will have a direct bearing on the planning of future work. In addition, valuable data were obtained on logging methods and equipment, sawmill operation, and the marketing of various forest products. Of the 80,000 board feet removed in the initial cut 45,000 were sawn into lumber for sale or use on the forest, 14,725 went into cross ties, 6,000 into box bolts, and the remainder into miscellaneous products or round fuelwood.

Aspen Study

A study was started to obtain information on the economic and pathological rotation for big-toothed aspen. Small patches of this species in pure or practically pure stands are common in northeastern Iowa and southeastern Minnesota. Aspen 12 to 14 inches in diameter and 60 to 80 years of age make up a considerable portion of the merchantable volume on the Paint Creek Experimental Forest, and there is a good local market for the species. However, the fact that many of these trees are decaying and dying poses a real problem. Further observation may show that even the currently thrifty individuals are poor risks to leave as growing stock and might better be harvested now.

Machine vs. Hand Planting

Twenty-seven acres of deciduous and coniferous plantations were established on the Paint Creek Experimental Forest during the spring of 1948. The plantings were made to compare machine and hand planting methods and to provide plantations for future management and silvicultural studies. The largest area planted was an old field of Fayette silt loan with 2 to 12 percent slope. Trees were planted on the contour. The species used and the areas of each are as follows: eastern white pine, 5.5 acres; white spruce, 3.7 acres; jack pine, 3.6 acres; and red pine, 4.8 acres. This field had been plowed during the year prior to planting and was double-disced before planting. One or two light rains had settled the soil somewhat prior to planting.

In another old field along Big Paint Creek, black walnuts that had been stratified over winter were planted in sod. This planting covered one acre. Two-tenths of an acre of cottonwood cuttings, 2.5 acres of conifers, and 2.8 acres of black walnut, silver maple, green ash, and cottonwood seedlings were also planted in sod. In addition, a small area of rocky bottomland along Big Paint Creek was planted to test the effectiveness of the planting machine under such conditions.

Under no condition of ground preparation and soil type were the trees as well planted with the standard planting machine tested as with experienced, supervised labor using hand tools. This was evident during planting and was further substantiated by survival counts made later in the season. One difficulty common to mechanical planting in both sod and prepared soil is that many trees are run over by the packing wheels and are left leaning heavily to one side or the other of the row. This is especially true on sloping, wet ground. Furthermore, unless great care is taken by the operator many trees are left leaning in the direction of travel. This is due to the effect of the packing wheels as they close the furrows about the trees and to the framework of the planter, which bends forward the tops of the taller trees. However, an experienced operator can largely overcome this difficulty by setting the trees at a reverse angle to compensate for the forward movement of the soil and the brushing effect of the planter framework.

Some difficulty was encountered in setting trees at a proper and uniform depth in prepared soil, and soil moisture content proved to be an important factor under such conditions. Because of the tendency of the wet soil to "ball up" on the plow, it was impossible to do an entirely satisfactory mechanical planting job in wet silty or clayey soils that had been plowed and disced previous to planting. It was also observed that in disced ground the tree roots were not as firmly packed by the machine as with hand planting.

In sod, however, the machine did a much better job. The firmer condition of the soil beneath the sod results in tighter packing of the tree roots. More trees are left in an upright position, and it is easier to set them at the proper depth. Moreover, even when wet, there is less tendency for the soil to "ball up" on the plow. Although no

tests were made, it is believed that the effectiveness of the planter on unprepared ground could be increased by the use of a sod-scalper attachment to turn back six to eight inches of sod on each side of the row.

In rocky or shallow soil the mechanical planter tested was very inefficient and did unsatisfactory work. The coulter throws the trench-opener or plow out of the ground so often that many spots with sufficient soil for planting are missed. Moreover, as the plow raises and lowers, it is difficult to set trees at the correct depth.

Experience in the machine planting of cuttings was essentially the same as with seedling stock. Except in shallow or rocky soils, the machine proved quite satisfactory for the planting of stratified nuts. However, care must be used to place the nuts at the proper depth; most operators tend to plant them too deep.

In this study a total of 26,247 trees were machine-planted in 47.5 hours, for an average of 550 trees per hour. This relatively low rate of planting was due to the small areas and short rows, which necessitated frequent turns and thus reduced the efficiency of the machine. Under more favorable conditions the planter should set about 1,000 trees per hour.

The average cost of machine planting was $13.47 per thousand trees. This cost included labor at $.85 per hour, power to pull the planter at $2.40 per hour, use of planter at $.40 per hour, and the handling of the planting stock. This figure, although considerably lower than hand-planting costs, is nevertheless higher than it should be. The reason is that a TD-9 crawler tractor, the only one available at the time, was used to pull the planter. This tractor provided more power than was needed and increased the planting cost accordingly. Using a farm-type tractor at an assumed rate of $.50 per hour, the cost of machine planting would be $10.03 per thousand. This compares even more favorably with the average hand-planting cost of $23.72 per thousand.

All factors considered, including costs, manpower requirements, and plantation survival, the planting machine tested seems preferable to hand-planting methods under most of the conditions of ground preparation and soil type included in this study. It is best adapted to open-field planting in moist, light soils. Even in heavy, wet soils the machine's disadvantages are more than compensated for by the ease of operation and the significantly lower costs. On the other hand, it is not well adapted for use in shallow or rocky soil.

Study of Old White Pine Plantation

Some interesting information on the growth and development of planted eastern white pine in Iowa was obtained from study of a 51-year-old unmanaged plantation near South Amana in Iowa County. The trees were planted by the Amana Society on a sandy ridge unsuited for cultivation.

Original spacing was approximately 7 x 8 feet. The present stand covers 6.1 acres, averages 425 trees per acre, and the average d.b.h. is 10.9 inches.

An average of 295 trees per acre are of sawlog size, averaging 11.7 inches d.b.h. and 34 feet of usable length. Site index is about 70 feet at 50 years. The present gross volume per acre is 6,976 cubic feet in all stems 4.6 inches and larger, and 33,467 board feet in trees 9.6 inches and larger. The average annual growth has been 137 cubic feet and 656 board feet per acre. This is significantly higher growth rate than can be expected of the native hardwoods even under intensive management.

The present average basal area is 274 square feet per acre. As shown by the basal area data presented in figure 4, diameter increment was greatest during the period when the trees were 22-31 years of age.

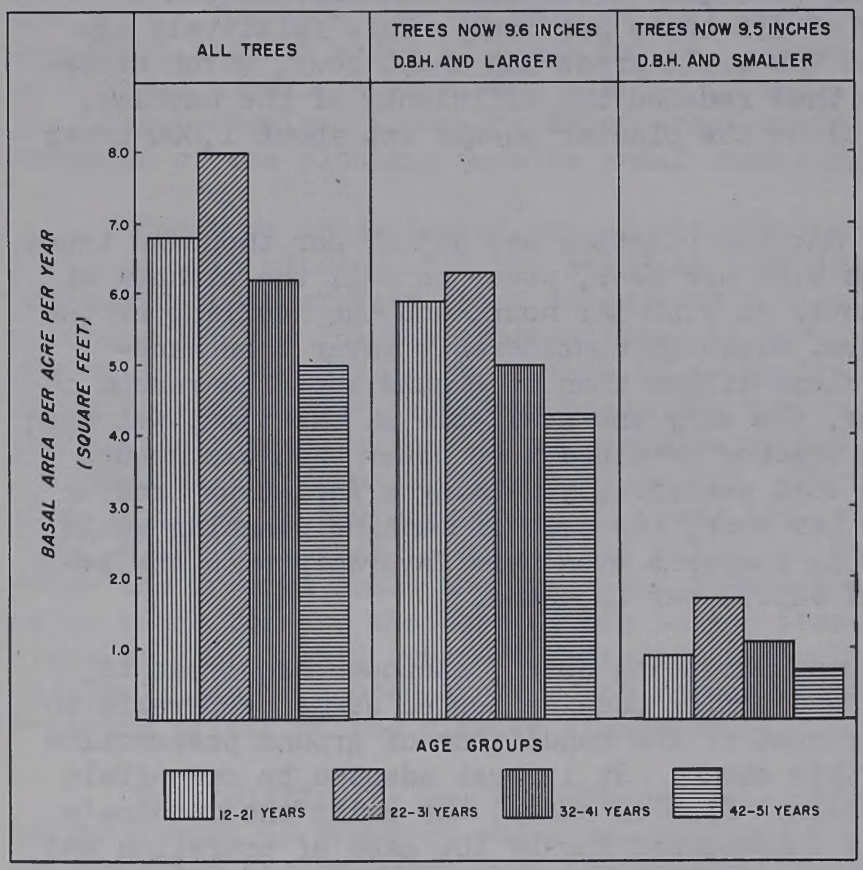


Figure 4.--Basal area increment of eastern white pine plantation by decades and diameter groups.

Diameter growth has shown a steady decline in subsequent decades, indicating overstocking and the need for thinning. Under management, this stand could have been made to increase in quality, and value at a greater rate and at the same time, assuming adequate markets, produce a substantial income through removal of surplus trees in thinnings and intermediate harvest cuttings. Nevertheless, this unmanaged plantation has provided valuable information on the potentialities of white pine planted on some of the poorer, sandy Iowa soils which are better suited to forestry than to agricultural crops.

Jack Pine Thinning Study

During the year a pruning study involving three intensities of pruning was started in a 10-year-old jack pine plantation in southeastern Iowa. Information on the effectiveness and cost of various pruning intensities is needed to guide the management of plantations which were established on a considerable acreage of submarginal agricultural land in southern and southeastern Iowa during the Civilian Conservation Corps program of the 30's. Of the various species of pine planted during this program jack pine has generally made the best growth, especially in the heavier, poorly drained soils common in that part of the state. In some cases the dominant trees in 10-year-old jack pine plantations have attained a height of 16.5 feet and an average diameter of 3.3 inches.

Management of Oak-Hickory Stands

A detailed working plan for a study of even-aged oak-hickory stands was prepared. The primary objective of this study is to determine the stocking necessary for maximum production of high-quality saw timber. Thinnings and intermediate harvest cuts of varying intensity will be made periodically in even-aged stands of three different age groups throughout a full rotation.

Plans for 1949

First priority will be given to making the initial harvest cut in the 70-acre farm forestry tract on the Paint Creek Experimental Forest. Inventory and detailed plans for the management of this unit were completed in 1948. Records will be kept on the costs of logging and milling and on the value of wood products produced. Following completion of the operation, a field day will be held to demonstrate to local timberland owners the methods and potentialities of intensive sustained-yield management of farm woodlots.

The program analysis of the Ames Research Center will be completed and submitted for review by the Advisory Committee.

The optimum-stocking study mentioned earlier will be established in oak-hickory stands on state forest lands near Farmington.

Results of observations on the 51-year-old white pine plantation near South Amana will be prepared for publication. In addition, plans for intermediate harvest cuts and thinning studies in this plantation will be developed.

Inventory of the Paint Creek Experimental Forest will be continued preparatory to the establishment of additional studies and the development of an over-all management plan.

BUCKEYE BRANCH

The Buckeye Research Center was established at Athens, Ohio, in July 1948 to conduct a program of research in timber management, forestation, and forest influences in Ohio and comparable forest areas in adjacent states. The total area served by this unit is 28.7 million acres, of which 5.1 million acres or 17 percent is forested. Included in the research center province are: Ohio, except for 16 counties in the northwest; that portion of Pennsylvania west of the Allegheny and Monongahela Rivers; and 10 counties of northwestern West Virginia. Also included, for purposes of spoil bank reclamation work only, are the coal fields of Kentucky. Although not homogeneous, the several parts of the territory served by the Buckeye Branch have many important similarities, including the problem of revegetating areas strip-mined for coal. Together they form a fairly distinctive section of the Central Hardwoods region.

The glaciated northwestern section of the province is characterized by gently rolling to flat topography, rich soils, intensive agriculture, and a concentration of industries in such large urban communities as Cleveland, Akron, Canton, Dayton and Columbus. Small, scattered farm woodlots make up the forests of this section. Dairying, corn-hog agriculture, and industry dominate the economy, and the trend is toward a decrease in forest acreage.

In the southern and eastern parts of the province the soils are poorer and the topography more rugged. Except for the Pittsburgh area and Cincinnati, there are fewer industries. Here forestry plays a much more important role in the local economy. Forests now occupy 30 to 50 percent of the land area of many of the counties. In addition, there are at least two million acres of rough, bare, eroding, nonproductive land in need of reforestation. It is estimated that one-third of this part of the province is best suited to forestry and allied uses.

Because of the nature of the country the trend is away from cultivated crops and toward improved pastures, forests, and allied uses. Except for the Wayne National Forest and the state forests, there are relatively few sizeable forest ownerships. However, an increasing number of large private owners, especially the coal and power companies, are enlarging their holdings with a view to growing timber for future use and income. There is a definite trend toward larger, more stable forest ownership in this part of the territory.

In order of their importance the major forest types of the province: oak-hickory, mixed hardwoods of more mesic species, oak-pine confined to the southern part of the province, and beech-maple found chiefly in the northern part of the province. Most of the second-growth hardwood stands which make up the forests of the province have been seriously depleted through frequent heavy cutting, grazing, and lack of protection from fire. They are generally understocked and contain a high proportion of culls and inferior species. Perhaps the greatest need for forest information is to determine and demonstrate how to rehabilitate these woodlands and to increase yields and financial returns to their full potential. Under

proper management the forests of the province, especially those of the southern and eastern part, could make an even greater contribution to the local economy. Yields could be increased at least threefold.

Another important problem is finding new uses and markets for low-quality hardwoods and inferior species, and developing more efficient logging equipment and methods. Research in planting is also needed to discover better methods and equipment for revegetating spoil banks and for planting rough, eroding, submarginal agricultural lands.

Better information on the role of forests in flood and erosion control is urgently needed to guide the forestry phases of the Department's land-use and flood control programs in the Ohio Valley.

Progress and accomplishments in 1948

Through cooperative arrangements with Ohio University office and laboratory space was provided in the Agriculture Building on the main campus at Athens, Ohio. Athens was selected as a headquarters site because it is centrally located with respect to the more heavily forested southern and eastern portions of the research center province, and because for the immediate future forestry leaders in the state have agreed that forest research should largely be concentrated on the problems of this territory. Here is found most of the publicly owned forest land, including the Wayne National Forest and most of the strip mines. Moreover, in this part of the province the trend is toward larger, more stable private ownerships; forestry can be expected to play an increasingly important role in the economy; and the major timber-management, planting, and flood control problems are more regional in nature. Most of the results of a research program aimed at the solution of these problems will be widely applicable throughout the more heavily timbered parts of the entire Ohio Valley.

The primary interest of the Ohio Agricultural Experiment Station, on the other hand, is in the small farm woodlots common to the northern portion of the province. This fact also influenced the decision to locate at Athens and to concentrate on the problems of the southeast. Accordingly, the Buckeye unit will do little research on small farm woodlots, except in cooperation with the state.

Good progress has been made toward equipping a laboratory to measure the physical properties of soil that affect tree growth and water retention and movement. Some of the equipment needed for contemplated research in the chemical and biological characteristics of soil and in plant physiology has also been purchased and installed.

A staff consisting of a research center leader, a silviculturist, a planting specialist, and a soil scientist has been recruited. All are expected to be on duty soon after January 1. This will complete the technical staff.

A preliminary analysis was made of the forest-influence problems of the Ohio Valley with special reference to the need for quantitative data on the effect of forests and other types of cover on the movement and retention of precipitation and on the development and stabilization of soils. In addition, two high-priority studies in this field were started during the year. In one, new and practical techniques and equipment were developed for measuring the effects of forest stands on the permeability and other biologically alterable characteristics of soils. Plans were also prepared and work started on a comprehensive study of the permeability and water-holding capacity of soils developed under various kinds of forest and other types of vegetative cover.

In the fall of 1948 plans were completed and work started on a regeneration study undertaken in cooperation with the Ohio Power Company. The company is supplying the land and financing the installation of the study. This study is expected to answer some important and highly controversial questions on ground preparation and planting methods. Eastern white pine and yellow-poplar will be planted on old fields using five methods of ground preparation and three methods of planting. These methods have been in common use, but have not previously been compared experimentally to determine which combination gives highest survival and most rapid growth for a given cost. The methods of ground preparation to be used in the experiment are (1) double-plowed furrows with the stock planted on the "lay" of the double furrow, (2) single-plowed furrows with the stock planted in the bottom of the single furrow, (3) scalps with the stock planted in the center of the scalp, (4) ground ripped with a road-ripper to a 2-foot depth and the stock planted in the "rip," and (5) no ground preparation. Three methods of planting will be used as follows: (1) mattock planting using the side-hole method, (2) bar planting using the slit method, and (3) planting with a modified commercial planting machine.

Three blocks will be planted to white pine and three to yellow-poplar. The ground preparation was completed in the fall of 1948, and planting will be done at a 6- by 6-foot spacing in the spring of 1949. A detailed soil map of the area will be prepared to permit correlation of survival and growth with soil characteristics.

With the exceptions noted above, no new studies were started in 1948. Plans for the long-range program will not be decided until the over-all program analysis is completed next year. Previously established studies in the province, chiefly experimental plantations on spoil banks in Ohio and Kentucky, were remeasured and otherwise maintained during the year.

A reconnaissance survey of various federal, state, and private lands was made preliminary to the selection of suitable experimental forest areas. Agreement was reached and action initiated to set aside for experimental use a 2,000-acre tract on the Ironton District of the Wayne National Forest near Ironton, Ohio. Preliminary discussions were also held with the Ohio Division of Forestry regarding the use of the 2-000-acre Dean State Forest, also near Ironton, for cooperative

experimental work. In addition negotiations were started for cooperative use of desirable privately owned timberlands.

Plans for 1949

The over-all program analysis will be completed during the year, and a long-range, comprehensive research program based thereon will be developed and submitted to the local Advisory Committee for review. When the research program is approved work plans will be drafted for high-priority studies scheduled for establishment.

Installation of the regeneration study started in 1948 will be completed, and the new work in forest influences and the older planting studies will be continued and maintained.

When final arrangements have been completed for experimental use of the 2,000-acre tract on the Wayne National Forest the area will be cruised and described in detail preparatory to formal dedication as an experimental forest. In addition detailed maps will be prepared showing forest type and condition classes, soil, topography, and other information needed to divide the area into suitable management compartments.

CARBONDALE BRANCH

Progress and accomplishments of the Carbondale Research Center during 1948 and plans for 1949 are presented under the following headings: (1) general, (2) timber management, and (3) reforestation.

General

One of the most important general developments during the year was the signing of a memorandum of understanding between the Central States Station and the Sahara Coal Company of Chicago and Harrisburg, Illinois. This agreement provides for cooperative harvesting and disposal of mine timbers and all other forest products scheduled for cutting in connection with forest management and other studies planned for the Kaskaskia Experimental Forest.

Plans were completed for a new road system at the Kaskaskia Experimental Forest, and construction was started on one of the primary roads which will provide ready access to the main body of timber on the forest. Further improvements were made in the buildings and the headquarters site, additional directional signs were erected, and trails were constructed to the natural area and to various experimental plots of general interest to visitors.

Timber Management

Progress and accomplishments in 1948

A study of growth and species evaluation of unmanaged stands of the two broad upland hardwood types on the Kaskaskia Experimental Forest was completed in 1948. Data on volume growth and stand structure of these important types were needed as a basis for comprehensive management studies being undertaken on the area. The results of this study were published in Station Technical Paper No. 110.

It was found that the mixed hardwood type (found chiefly in the coves and northerly slopes) differed greatly from the oak-hickory type (found chiefly on the ridges and southerly slopes) in growth, volume, and basal area. Board-foot growth was 100 percent greater and board-foot volume was 50 percent greater in the mixed-hardwood type than in the oak-hickory type. Yellow-poplar made the greatest relative cubic-foot growth contribution to the total stand. Black and red oaks were next and white oak followed. Hickory, post oak, and blackgum made relatively poor growth in relation to their basal area representation in the stand (table 8). About 15 percent of the average basal area per acre of each type was occupied by cull trees. When culls and species with the lowest ratio of growth to basal area are combined, 55 percent of the basal area of the mixed-hardwood type and 40 percent of the oak-hickory type is made up of the less desirable trees. When to this are added the "poor-risk" merchantable trees, the importance and magnitude of the forest management job becomes even more apparent.

Table 8.--Ratio of cubic-foot growth percent[1/] and basal area percent[2/] by species and broad type

Species	Mixed-hardwood	Oak-hickory
Yellow-poplar	1.80	-
Black oak	1.28	1.24
Northern red oak and southern red oak	1.25	-
Scarlet oak	1.15	1.60
White oak	1.04	1.13
Southern red oak	-	0.92
Post oak	-	0.62
Hickory	0.63	0.53
Miscellaneous	0.38	-

1/ Cubic-foot merchantable-stem growth of each species expressed as a percent of total growth of the stand.

2/ Square-foot basal area of each species expressed as a percent of total basal area of the stand.

Recommendations for the conversion and subsequent sustained-yield management of these previously unmanaged stands include the following:

1. One or more improvement cuts to eliminate all culls and all defective or poorly formed trees.

2. In the mixed-hardwood stands, discriminate against hickory and blackgum of all sizes, and favor yellow-poplar, white oak, northern red oak, and black oak. In marking, scarlet oak should be scrutinized carefully for quality and defect, and should be grown on a short rotation.

3. In the oak-hickory stands, discriminate against hickory and blackjack oak. Favor white oak and black oak on the better sites and black oak, southern red oak, and post oak on the poorer sites.

Another study completed during the past year was a stand objective study, which involved examination of some of the best upland hardwood stands that could be found in southern Illinois. Data were obtained on such factors as stocking, species composition, diameter distribution, growth, and economic maturity of individual trees. The purpose of this study was to obtain more complete information on the best present stands to serve as a guide in the management of the two broad upland forest types of southern Illinois until optimum stockings are determined through research.

The stands examined were unmanaged, and for this reason do not represent the best growth and yield that the local upland sites are capable of producing under the best forest practices. Nevertheless, the growth and yield of these unmanaged stands is at least indicative, and is the best currently available evidence of what may be expected of such stands under optimum conditions of stocking and management. Since growth and yield vary by site and forest type, it was found advantageous to group the data according to type-site classes on the basis of the two important types and the height of mature dominant trees. Five type-site classes are proposed for the upland region of southern Illinois. The data shown in table 9 represent the best growth, height and volume found in existing unmanaged stands. These tentative management goals will be corrected and improved as the results of long-time management studies now in progress become available.

In comparison with well-managed stands, those examined were overstocked. Annual growth per tree on individual dominant and codominant saw-timber trees was decreasing. The data show that volume maturity for the desirable species on the better sites is reached when the trees are about 22 inches in diameter and on the poorest sites when the trees are 17 inches in diameter. If the smaller trees were released, the resulting increase in growth of the smaller stems would probably more than offset the growth lost on the large trees removed. Value per thousand board feet, based on log grades, levels off at about 19 inches d.b.h.

Table 9.—Basal area, volume, and growth for several type-site classes important in southern Illinois[1/]

Type-site class: Forest type	(Height dominant mature trees)	Basal area per acre[2/]	Volume per acre[2/]	Annual growth per acre[2/]
	Feet	Sq. ft.	Cu. ft.	Cu. ft.
Mixed hardwood	90 plus	129	2,540	64.0
Mixed hardwood	81-89	103	2,800	49.8
Mixed hardwood	70-80	97	1,700	37.5
Oak-hickory	65-75	82	1,300	25.2
Oak-hickory	Less than 65	77	960	16.9

1/ Based on 20 sample stands. Stands were unmanaged and fully-stocked, i.e., all crown space was occupied by trees.
2/ In all merchantable or potentially merchantable trees more than 4.5 inches in diameter at breast height.

During the spring of 1948 a thinning and pruning study was started in a 13-year-old shortleaf pine plantation in the uplands of southern Illinois. The objective was to determine how to handle such plantations to obtain maximum growth and quality. Work in other regions indicates that a basal area of 80 square feet per acre is about the minimum desirable stocking for young southern pine plantations. This was assumed to be approximately correct for similar stands in southern Illinois, and the thinning was done on this basis. The thinning removed 207 trees per acre, yielding 240 marketable fence posts and 70 unmerchantable posts. The merchantable posts were seven feet long and had a top diameter of three inches or more. At 5 cents per marketable post, the stumpage value of the trees cut was $12.00 per acre. The total volume of wood removed in the thinning was equivalent to 3.7 cords of pulpwood per acre. Since there are no local markets for pine pulpwood, the pulpwood stumpage values could not be estimated. Projection of current growth rates indicates that in 1953 the plantation will have 135 square feet of basal area and 23 cords of wood per acre. A second thinning will be necessary at that time if a satisfactory growth rate is to be maintained. The pruning phase of the study indicates that about two-thirds of the live crown of shortleaf pine can be removed without seriously retarding height and diameter growth.

Plans for 1949

The cutting and harvesting phases of the comprehensive management study established on the Kaskaskia Experimental Forest will be initiated

in January 1949. Six compartments included in this long-range study are scheduled for cutting during the year. In addition, two farm-forestry tracts and six cutting-practice demonstration areas will be cut or otherwise treated. A total of approximately 225,000 board feet of wood products will be harvested from these experimental areas during the year.

A stand-conversion study designed to explore the possibilities of converting poor-site oak-hickory stands to a mixture of oak and conifers will be established during 1949. Plans call for the planting of shortleaf pine and redcedar in understocked areas and suitable-sized openings created by the removal of cull and defective trees.

Thinning studies will be established in dense pin-oak stands on the oak flats common to southern Illinois, and on similar areas in adjacent states, and in some of the older loblolly pine plantations on claypan soils of southern Illinois. These studies will be conducted on cooperation with the Shawnee National Forest and the Chicago, Wilmington, and Franklin Coal Company.

A reconnaissance survey of the older pine plantations in southern Illinois will be completed, and a problem analysis of plantation management made. This work will lay the foundation for plans to attack the whole problem of plantation management on a more adequate basis. Much of the 30,000 acres of pine plantations on the Shawnee National Forest and the small planted areas elsewhere will soon need thinning, pruning, and other cultural treatments. Additional areas are planted each year. There is, therefore, an urgent need for better information on how to handle these plantations to assure maximum yield and financial return.

Reforestation

Progress and accomplishments in 1948

Eight-year-old plantations of shortleaf, loblolly, pitch, and Virginia pines on typical claypan soils of southern Illinois were examined during 1948. Results were analyzed and summarized in Station Note No. 44. Survival was good for all four species. Virginia and pitch pine had the poorest form and slowest growth. Loblolly pine averaged 20 feet in height and shortleaf 14 feet. Both of these species had satisfactory form but shortleaf was somewhat straighter, cleaner, and less subject to snow and ice damage. Either loblolly or shortleaf pine will produce mine props or posts on these claypan soils, but shortleaf should probably be favored for longer-rotation products.

Black locust plantations 10 to 12 years old on similar claypan soils were definitely a failure. The trees were stagnated, broken, riddled with borers, and many were dead. Failure of more than 100 acres of black locust plantations on these sites was recognized by the private owners. The land is now being replanted to shortleaf pine for production of mine props and timbers. The condition of the locust plantations, site descriptions,

and costs of converting to shortleaf pine were summarized in Station Note No. 46.

Thirteen-year-old plantations of shipmast and common black locust established in the uplands of southern Illinois were examined and the results summarized in Station Note No. 45. The shipmast locust was grown from root cuttings originating on Long Island, New York, and the common black locust came from seed from southern Indiana. The shipmast strain was not significantly different from common black locust in survival, growth, or form. Superior strains of trees transported to places of greatly differing climate and soil do not always reproduce their desirable characteristics.

Direct seeding studies were established in the uplands of southern Illinois during the fall of 1947 and spring of 1948. Loblolly pine, shortleaf pine, and redcedar were seeded on different sites by hand and machine methods. At the end of the first summer, direct-seeded shortleaf and loblolly pine showed good success on sites with a moderate-to-heavy ground cover of broomsedge or other low vegetation. Spring-seeded shortleaf pine from stratified seed gave the best results for both the hand method (drilled in small scalped spot) and the machine method (plowed shallow furrow). Redcedar seed did not germinate and further tests are required.

In the fall of 1947 and spring of 1948 shortleaf pine was planted on 40 one-fifteenth-acre plots in the uplands of southern Illinois. Eighty trees were planted on each plot. Half of each plot was planted in the fall and the other half in the spring. Four different planting methods were employed: (1) side-hole with 10-inch scalp, (2) side-hole without scalp, (3) mattock-slit with 10-inch scalp, and (4) mattock-slit without scalp. All plots were examined during the fall of 1948. Of the 40 spring-planted plots, only two had less than 80 percent survival. The average for all spring-planted plots was 90 percent. One hundred and seven trees per man-hour were planted using the mattock-slit method without scalp. Of this number, 83 percent lived through the first growing season. Using the mattock-slit method with scalp, 69 trees were planted per man-hour, of which 94 percent survived the first growing season. The side-hole method, with and without scalp, gave 90 percent survival, but required more time for planting. Height of trees at the end of the first year was the same for all methods.

Late fall planting was generally less successful than spring planting, but plots planted in December by the side-hole method with a small scalp had an average survival of 76 percent. Survival of fall-planted trees was better than this on areas with heavy broomsedge cover. Frost-heaving was a negligible factor in the mortality of fall-planted trees on areas with moderate-to-heavy ground cover. Mortality apparently was caused by desiccation of trees during the winter. Early fall planting should allow enough root development to avoid winter desiccation and consequent losses. Spring planting was uniformly successful on all sites and for all methods used.

During the spring of 1948 a study was conducted to determine and to demonstrate the relative survival and costs of planting shortleaf pine by four hand methods and one machine method. This study was established in the Shawnee National Forest on typical upland old-field planting areas. Two ½-acre plots were planted by each method. One-year-old stock was planted at a 7- by 7-foot spacing. First-year survival counts were made in the fall of 1948 (table 10).

Table 10.—Planting time and survival percent for several methods of planting shortleaf pine in southern Illinois

Planting method	Man-hours to plant one acre	Trees planted per man-hour	Live trees obtained per hour [1/]	Survival [1/]
	Number	Number	Number	Percent
Mattock, slit with 18-inch scalp	11	80	76	95
Contour furrow, mattock, side-hole [2/]	10	91	86	95
Mattock, side-hole without scalp	6	140	127	91
Bar, slit without scalp	5	171	150	88
Standard planting machine [3/]	1	969	948	98

1/ At end of first growing season.
2/ Includes two men, breaking plow, team and 5-man planting crew.
3/ Includes two men, small crawler tractor, and planting machine.

In terms of survival, planting time, and planting costs per acre (figure 5) the planting machine proved to be superior to the other methods tested. However, performance of the machine was disappointing under certain conditions of soil and cover. Except on heavily eroded areas the upland planting sites are commonly heavy yellow clay and are covered with broomsedge or brush. During the spring planting season the soils are usually very wet. Under these soil conditions the machine does not plant successfully on the scantily covered eroded spots and is only fairly successful in heavy broomsedge. It is of limited use in the brushy areas. In other studies initiated last fall similar results were obtained when the soil was very wet. If fall or spring planting can be done while the soil is fairly dry, the machine offers considerable promise on all areas except those having a dense brush cover. Otherwise, planting with the standard machine used in this study appears to be impractical in the heavy clay soils of southern Illinois.

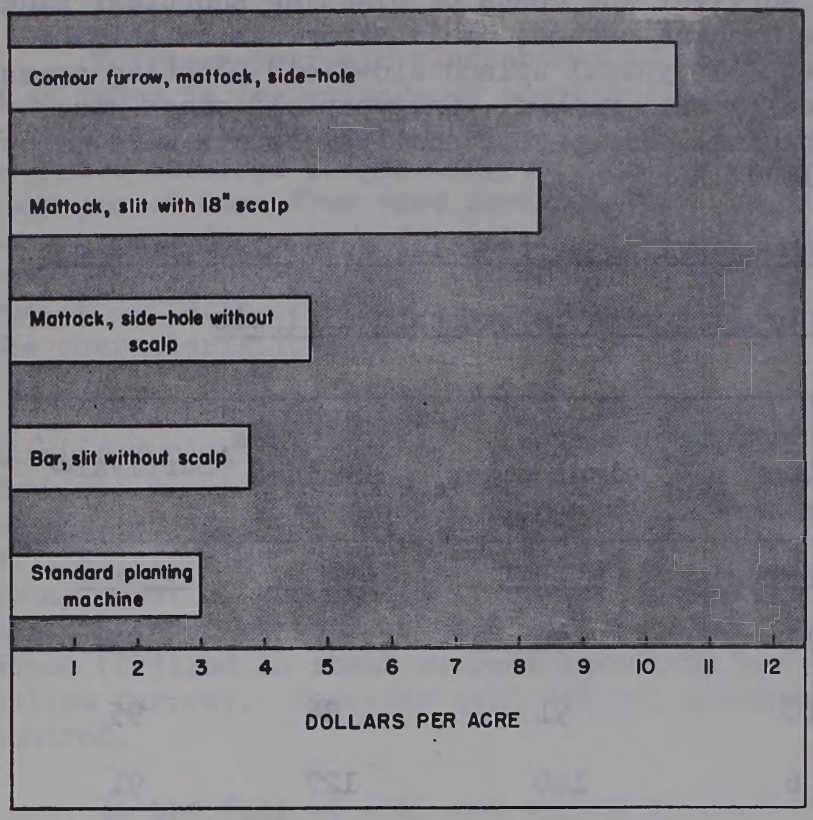

Contour furrow, mattock, side-hole
Mattock, slit with 18" scalp
Mattock, side-hole without scalp
Bar, slit without scalp
Standard planting machine
1 2 3 4 5 6 7 8 9 10 11 12
DOLLARS PER ACRE

Figure 5.--Current planting costs for several planting methods.

A working plan for a study to determine the effect of geographic source of seed on the growth of shortleaf and loblolly pine and eastern redcedar was completed. Replicated plots were selected and laid out in both the upland and claypan soils of southern Illinois. Planting stock from seven sources of shortleaf pine seed and six sources of loblolly pine seed is now being grown in the Union County State Nursery. Eastern redcedar from eight sources has been planted in the Mason County State Nursery. In addition, two pine hybrids have been grown from seed furnished by the California Forest and Range Experiment Station.

During October 1948, a fall planting study was established in the uplands. Approximately 1 acre of 1-0 shortleaf pine seedlings was planted by each of the following methods: (1) the most successful fall planting hand method (side-hole) found in the previously established fall versus spring planting experimental plots, (2) the cheapest hand method (slit without scalp), and (3) the standard planting machine used in the spring planting studies.

Results from these and previously established fall and spring planting plots will provide the basis for determining relative success and costs for fall and spring planting by several methods. Site and cover type conditions necessary for fall-planting success can be described. These plots will also provide a basis for estimating probable loss in survival in fall planting. This disadvantage can be weighed against the work load and other advantages of fall planting. Fall planting with the

machine appears feasible and convenient if the soil is not too wet. The current tests will show whether survival is good enough to warrant use of the planting machine in the fall.

During the spring of 1948, a study was initiated to determine and demonstrate the survival, growth, and costs and returns of growing Christmas trees on lands stripped for coal. One acre each of red and jack pine and eastern redcedar was planted. The study was undertaken jointly by the Illinois Central Railroad, the Illinois Coal Strippers Association, the United Electric Coal Company, and the Carbondale Branch Station.

Plans for 1949

A problem analysis covering all phases of planting and seeding in the Carbondale province will be completed during the year. This analysis, now in rough draft, will focus attention on important regeneration problems, provide a better basis for determining priorities, and serve as a guide in the development of plans for future research in seeding and planting, including stand conversion and reinforcement planting in existing stands.

Going studies will be continued and the results summarized for publication, the more promising methods and species will be tested on a pilot plant scale, and new research started as needed.

NORTHERN OZARK BRANCH

The Northern Ozark Research Center was established in July 1948 to help solve the forest, forest range, spoil bank reclamation, and water-conservation problems in the Missouri Ozarks and surrounding areas, including the strip-mined lands of the eastern Kansas, northeastern Oklahoma, and northwestern Arkansas coal fields. The total area of the province served by this unit is 54 million acres, of which 19 million acres are in forest or forest range. In addition, there are an estimated 3 million acres of potential forest land in the problem area of the Northern Ozark Research Center. Included in the latter category are strip-mined lands in need of planting, abandoned fields which are reverting naturally to forest cover, and exhausted, eroding, submarginal agricultural lands for which forestry is probably the highest use.

The Ozark area is rather distinctive and in many respects is unlike bordering lands included in the province on the basis of location and common problems in strip mine reclamation and farm forestry. The Missouri Ozarks are relatively homogeneous from the standpoint of physical features, forest and range conditions and problems, and history. The area is a deeply dissected plateau, one of the oldest geologic formations in the country. Rough terrain, shallow and rocky soils, excessive run-off and

subsurface drainage, high evaporation rates, and poorly distributed rainfall give it a fairly dry site. Prior to settlement this area supported a relatively uniform forest of high-quality oak, pine, and other species. Bordering on the prairie as it does, many prairie peninsulas and islands were present. Also many of the forest stands in the forest-prairie tension zone contained varying amounts of prairie vegetation.

At the present time about 55 percent of the land is forested. This percentage varies by county from less than 10 percent to about 90 percent. Furthermore, the existing stands have been so badly overcut that they average less than 650 board feet of merchantable timber per acre. As the forests were depleted and the primary source of income thus reduced, there was a gradual shift to stock-raising and to cultivating the land for additional income. Although the total acreage of forests has remained fairly constant since the depression years, there has been a gradual shift from cultivated crops to pasture and from open range to improved pasture. In spite of the depleted condition of the forest and the generally low fertility of the bare lands, the income of most of the people in this area is still obtained from forests, pasture, and cultivated crops.

Most of the land now forested is, by present standards, unsuited for any other use. Just as some areas, particularly those bordering the prairie, may have possibilities for pasture, so some of the cleared land probably should be returned to forests. The extent of these borderline lands, and the use to which they should be put for the greatest good to all the people, remains to be determined. It should be remembered, however, that most of the people in this area have a woods background. Although they may have been forced to other work, even to seeking employment in town, they are fundamentally woods people and many will return to woods work at the first opportunity.

Except for large tracts of land owned by the Federal Government, the state, and a few companies and individuals, the forests are mostly in small ownerships. Most of the forest land is owned by farmers, who often find it necessary to harvest trees as soon as they are merchantable and to run stock in the woods to supplement their meager incomes from cultivated lands. Overcutting, overgrazing, and frequent burning are primarily responsible for the depleted condition of the stands today. In spite of the fact that these stands contain less than 650 board feet of merchantable timber per acre, the various owners and some 1,000-1,500 sawmill operators manage to harvest an equivalent of approximately half a billion board feet per year. Unless the growth is increased or the cut decreased, or both, the productivity and quality of the forest cannot be improved.

The forests in this area are predominantly oak-hickory or some variation of this type. One exception is a sizable area of redcedar in the glade-like White River drainage and in other smaller areas throughout the Ozarks. The rather limited but important bottomland hardwoods type along the main rivers is another exception.

The oak-hickory type has several subtypes, varying from the relatively vigorous, high-quality stands on the loess-capped "river breaks"

and the lower slopes and coves to the poor scrub-oak stands on the narrow ridges and on the shallow soils underlain with hardpan. From the point of view of potential income per acre, the most important of these is the oak-pine forest centering in and around, Shannon, Carter, and Reynolds Counties. This type occupies some 5 million acres and is the most productive type in the region. Although the oak-hickory subtypes differ in composition, quality, and potential productivity, the problem of rebuilding them and keeping them productive is essentially the same.

The shift to livestock production following the depletion of the forest resource during the World War I period was not accompanied by a corresponding shift to improved pastures. Moreover, the production of winter feeds did not keep pace with the increase in numbers of livestock. In many instances, therefore, farmers were forced to a year-round use of the range. Consequently, the open and forest ranges were soon overgrazed. When the sprout reproduction began to shade out the grass, the cattlemen resorted to burning as a means for reducing this competition. Although fairly successful in keeping the sprouts down and in postponing the doom of some of the forage plants, periodic burning neither eliminates the sprouts nor guarantees a continuous crop of forage. After the litter, humus, and forage plants have been burned periodically for many years the site becomes less and less productive. Also, repeated burning and persistent overgrazing so changes the species composition of the range vegetation that the little forage that is produced is very low in food value. Although there has been a gradual shift to improved pastures during the last several years, many people still derive their income from cattle that graze almost exclusively on the forest range.

Overgrazing, overcutting, and burning of the forests and forest ranges have greatly increased erosion, have accelerated run-off, and have generally lowered the ground-water level throughout the area. Stabilization of the soil and control of run-off through land-use measures, including range reseeding and the rehabilitation of depleted forest stands, are of major importance throughout the Northern Ozark territory.

Those portions of Kansas, Oklahoma, and Arkansas included in the Northern Ozark research center province vary from the sparsely wooded plains sections of eastern Kansas and northeastern Oklahoma to the heavily forested, rough lands of northwestern Arkansas. Research on the character and forestation possibilities of lands stripped for coal--a problem common to the entire area--is the basis for including these lands in the Northern Ozark province. To date approximately 40,000 acres have been strip-mined in Kansas, Oklahoma, and Arkansas, and an additional 26,000 acres have been stripped in Missouri. In view of the rich and extensive seams of coal relatively near the surface in the coal-field sections of these states, it is anticipated that a considerably greater acreage will be stripped in the future. All Forest Service reclamation research west of the Mississippi will be handled by the Northern Ozark unit. This is a part of a regional study authorized by Congress several years ago.

Major problems of the Northern Ozark province include: (1) improving the stocking, species composition, and growth rate of depleted forest

stands; (2) finding new uses and markets for low-grade and inferior hardwoods; (3) developing better logging equipment and methods; (4) determining the most effective land-use measures for stabilizing soil and controling run-off; (5) developing more efficient methods and equipment for planting spoil banks and other areas in need of planting; (6) improving the depleted forest range; and (7) determining the proper integration of grazing and timber management. The program of the Northern Ozark research center will be directed toward the solution of these and other major forest and range problems to which research can help provide answers.

Progress and accomplishments in 1948

Work during 1948 consisted chiefly of recruiting a technical staff, selecting experimental forests and a headquarters office, assembling equipment and supplies, arranging for cooperation with local agencies, setting up an Advisory Committee, developing the framework of a research program, and maintaining going studies.

The present technical staff consists of a research center leader, a forest management specialist, and a range management specialist. A specialist in soils and planting will be added to the staff next year.

Headquarters for the research center were established at the University of Missouri, Columbia, Missouri. This cooperative arrangement makes available office space, the library, and other facilities of the University. Most of the agencies with which cooperative work will be done are headquartered either in Columbia or nearby Jefferson City. This will facilitate coordination of efforts and the development of a well-integrated overall program of forest and range research. Cooperative agreements with the University of Missouri and the Missouri Conservation Commission are already in effect. Similar agreements will be made with other public agencies and private concerns as the program develops.

After careful examination of available areas, a 4,000-acre tract on the Clark National Forest in Dent and Reynolds Counties was selected as the first experimental forest. This area supports a second-growth oak-pine stand ranging in composition from pure stands of oak to pure stands of pine. Most of the forest management research planned for the next few years will be concentrated on this area. Additional experimental forests will be established as required for work in other types.

Most equipment and supplies needed for the present have been acquired by purchase or made available by the University of Missouri and other cooperators. The few additional items planned for purchase next year will take care of the most important needs during the early phases of the work.

Eight individuals representing various forest and range interests in the area were invited and agreed to serve on the research center's Advisory Committee. Preliminary plans were approved at the first formal meeting of this group. Other interests will be invited to serve on this Committee as the program develops and expands.

A start was made on the reexamination and remeasurement of plots established in 1938 in oak-pine stands to determine the effects of overhead release on the growth and development of hardwood reproduction and of natural and planted pine reproduction. Maintenance work was continued on other studies started prior to the establishment of the center.

Plans for 1949

The most important job in 1949 will be the completion of the over-all program analysis and the development of a research program based thereon. The analysis will consider all major forest, range, and forest-influence problems of the area and will determine the relative importance and the priority of each. Program development will be guided by priorities thus established, by personnel and facilities available, by cooperation expected, and by similar considerations. The tentative program will be submitted to the Advisory Council for comment and approval prior to the development of detailed work plans or the initiation of new and important projects.

Preparation of detailed work plans for major new research projects--an important task--will of necessity be deferred until the over-all long-range program has been developed and approved. In the meantime, some preliminary work will be started on weed control in forest nurseries, brush and sprout eradication in forest pastures, and natural regeneration in forest stands. Also, remeasurement and maintenance work will be continued on the older studies.

The survey and description of the Sinkin Experimental Forest in Dent and Reynolds Counties preparatory to formal dedication of this tract as an experimental forest, is another high-priority job that will be completed during 1949. The area will be cruised and detailed maps prepared showing forest type and condition classes, soil, topography, and other pertinent data needed to divide it into suitable management compartments. Consideration will also be given to development of plans for a road system. Insofar as possible experimental areas in other types will be selected and action started to reserve them for future experimental work.

The Northern Ozark research center has been invited by the University of Missouri to cooperate in developing a research program for a 7,000-acre area at Weldon Springs, which was recently turned over to the University for research purposes. This tract can be developed into an excellent experimental forest and range. Every possible effort will be made to assist with the preparation of a sound research program for this area.

COOPERATIVE FARM FORESTRY RESEARCH

OHIO PROJECT

Progress and accomplishments in 1948

Little progress was made on this project during 1948. An article entitled, Factors Influencing the Yield and Cost of Maple Syrup, by W. R. Anderson, J. S. Ball, H. R. Moore, and Richard Baker was prepared by publication in Ohio Farm and Home Research.

Plans for 1949

Present plans call for the closing out of this project with a joint publication between the Departments of Rural Economics and Forestry of the Ohio Agricultural Experiment Station.

IOWA PROJECT

Progress and accomplishments in 1948

Station Note No. 43 entitled, Preliminary Report of Yields of Lumber by Grades from Iowa Timber, was issued.

Plans for 1949

Present plans do not call for further work on this project during 1949. It is planned however, that Mr. Kellogg of the Iowa State College of Forestry will complete the analysis of these data and prepare a final report during the summer of 1950.

ILLINOIS PROJECT

Field work for the cooperative study of the veneer container industry in Illinois was completed in February 1948. A manuscript summarizing the results was prepared and submitted to the Editor of the Illinois Agricultural Experiment Station in July 1948. It is expected that the report will be published during 1949.

MISSOURI PROJECT

During 1948 a study of the forest plantations in Missouri was initiated by the Missouri Agricultural Experiment Station. Since early 1936

approximately 14 million trees (Clark-McNary stock furnished by the state) have been planted throughout the state. The success of individual plantations varies from quite satisfactory to complete failure. This is not surprising since the trees were planted by many different people, by various methods, on a wide variety of sites, largely without technical supervision, and with only very general directions for planting. Since tree planting will continue to be an important part of Missouri's forestry program, every effort should be made to secure information that will help plant the right tree in the right place at the right time.

The general objective of the forest-tree plantation study is to provide information of this kind. More specifically, the objectives are (1) to determine the extent to which the survival and early growth of the trees of the different species were affected by various factors of site, kind and condition of planting stock, planting methods, and plantation care, and (2) on the basis of this information, to prepare a planting guide for use in subsequent forest-tree plantings.

Progress and accomplishments in 1948

The work on this study in 1948 was limited to (1) making preliminary field examinations to provide a better basis for planning the details of the study, (2) obtaining a list of plantations and their locations, (3) determining the number of plantations to be sampled and developing a suitable technique for selecting them, and (4) deciding what data should be taken and preparing suitable field forms.

Plans for 1949

A detailed work plan for the study will be completed early in 1949. Actual examination of the plantations and collection of field data will start in April and continue through the summer. Analysis of the data will be made during the fall and winter.

PERSONNEL

(December 31, 1948)

ADMINISTRATION

HAROLD L. MITCHELL, Director; Jean R. Donahue, Secretary

HERBERT C. BRADSHAW, Administrative Assistant; M. Jeannette Morgan, Mary L. Posey, Laura C. Sisk, Bertha G. Bartram, Frances J. Englehard, Ruth L. Hughes, Evelyn E. Vukovich, Dorotha M. Perkins, Eileen Wein, Mary G. MacDonald, Faith Holliday, Thomas W. Crossley, James R. Davis

ECONOMICS DIVISION

ROBERT K. WINTERS, Chief; Virginia K. Tomlinson, Secretary

Survey Inventory — Eugene V. Roberts

Field Project — Maxwell E. Becker, Theodore J. Schmitt, Edwin F. Youngblood, Robert E. Doyle, William T. Plass

Photo Interpretation — Karl E. Moessner, Forrest D. Brunson, Chester E. Jensen, Karl W. Chrisemer

Growth and Statistical Procedures -- G. Luther Schnur

Commodity Drain — James T. Morgan

Computing — Lake F. Compton, Margaret K. Peirsol, Mary L. Sterner

Forest Resources Analysis -- David B. King

Farm Woodland Marketing Studies — Robert K. Winters, Kenneth L. Quigley, O. Keith Hutchison

FOREST MANAGEMENT DIVISION

ARTHUR G. CHAPMAN, Chief; Alberta M. Hiatt, Secretary

Soils -- _____

Mensuration — G. Luther Schnur

Silviculture — Gustaf A. Limstrom, Charles Christian, Jr.

FOREST UTILIZATION SERVICE

_____, Chief

Primary Industries -- Ralph K. Day

Secondary Industries -- Marsden R. Brundage

FLOOD CONTROL

HAROLD F. MOREY, John T. Auten, L. F. Kellogg, Leona B. Kale

BRANCH STATIONS

CARBONDALE BRANCH -- Richard D. Lane, Leon S. Minckler, Glenn H. Deitschman (Spoil Bank Specialist), Cleo Caraway

Post Office Building
Carbondale, Illinois

Kaskaskia Experimental Forest -- Donald L. Fassnacht, R. K. Train
Elizabethtown, Illinois

AMES BRANCH -- E. Garth Champagne, Kenneth A. Brinkman, Barbara L. Ward
c/o Forestry Department
Iowa State College
Ames, Iowa

Paint Creek Experimental Forest -- John E. Krajicek
McGregor, Iowa

BUCKEYE BRANCH -- _____, Robert W. Merz, Richard N. Gaiser, Raymond F. Finn
c/o Ohio University
Athens, Ohio

NORTHERN OZARK BRANCH -- Franklin G. Liming, Hilda Stankunas
c/o University of Missouri
Columbia, Missouri

Sinkin Experimental Forest -- Nelson F. Rogers, Wayne M. Harrison
c/o U. S. Forest Service
Salem, Missouri

PUBLICATIONS FOR 1948

Brundage, M. R.
1948 Detecting metal in logs. Wood 3(5):15-17.

1948 Electronic detection of concealed metal in timber. Proceedings 24th National Shade Tree Conference: 74-80.

Carbondale Branch Staff
1948 Kaskaskia Experimental Forest, Carbondale Branch Station. Central States Forest Experiment Station. Miscellaneous Release No. 2.

Chapman, A. G.
1948 Cover for the spoil banks. The Land 7(1):41-45.

1948 More efficient uses for stripped lands. American Mining Congress Year Book, Coal Mine Modernization: 291-295.

1948 Survival and growth of various grades of shortleaf pine planting stock. Iowa State College Journal Science 22(4): 323-331.

Columbus Station Staff
1948 Station Correspondence Style Manual. Central States Forest Experiment Station. Miscellaneous Release No. 3.

Fassnacht, Donald L., and Train, Robert K.
1948 Tree defects common in the upland forests of southern Illinois. Central States Forest Experiment Station. Station Note No. 49.

Forest Survey Organization
1948 Forest resources of the eastern Ozark region in Missouri. Central States Forest Experiment Station. Forest Survey Release No. 1.

1948 Forest resources of the southwestern Ozark region in Missouri. Central States Forest Experiment Station. Forest Survey Release No. 2.

1948 Forest resources of the northwestern Ozark region in Missouri. Central States Forest Experiment Station. Forest Survey Release No. 3.

Forest Survey Organization
1948 Forest resources of the Prairie region in Missouri. Central States Forest Experiment Station. Forest Survey Release No. 4.

1948 Forest resources of the Riverborder region in Missouri. Central States Forest Experiment Station. Forest Survey Release No. 5.

1948 Forest resources of Missouri. Central States Forest Experiment Station. Forest Survey Release No. 6.

Hutchison, O. Keith
1948 Aerial photo alignment guide. Central States Forest Experiment Station. Station Note No. 50.

Jensen, Chester E.
1948 Dot-type scale for measuring tree-crown diameter on aerial photographs. Central States Forest Experiment Station. Station Note No. 48.

Kellogg, L. F.
1948 Volume table for black walnut trees in natural stands in Iowa. Central States Forest Experiment Station. Station Note No. 42.

--- and Hartman, George B.
1948 Preliminary report of yields of lumber by grades from Iowa timber. Central States Forest Experiment Station. Station Note No. 43.

Lane, Richard D.
1948 Science goes to the forest. Illinois Wildlife 3(2):10-11.

--- and Fassnacht, Donald L.
1948 Young pine plantation thinnings yield merchantable products. Central States Forest Experiment Station. Station Note No. 51.

--- and McComb, A. L.
1948 Wilting and soil moisture depletion by tree seedlings and grass. Journal Forestry 46: 344-349.

Liming, Franklin G.
1948 The place of forest research in Missouri. The Missouri Log 1: 15-18. University of Missouri, Columbia, Missouri.

Limstrom, G. A.
1948 Extent, character, and forestation possibilities of land stripped for coal in the central states. Central States Forest Experiment Station. Technical Paper No. 109.

Minckler, Leon S.
1948 Planted black locust on claypan soils of southern Illinois. Central States Forest Experiment Station. Station Note No. 46.

1948 Planted pines on claypan soils of southern Illinois. Central States Forest Experiment Station. Station Note No. 44.

1948 Shipmast vs. common black locust in southern Illinois. Central States Forest Experiment Station. Station Note No. 45.

--- and Chapman, A. G.
1948 Tree planting in the Central, Piedmont, and Southern Appalachian regions. U. S. Department of Agriculture Farmers' Bulletin No. 1994.

--- and Fassnacht, Donald L., and Train, Robert K.
1948 Growth and species evaluation of some unmanaged upland hardwoods in southern Illinois. Central States Forest Experiment Station. Technical Paper No. 110.

Moessner, Karl E.
1948 The aerial photo scale. Journal Forestry 46: 843-844.

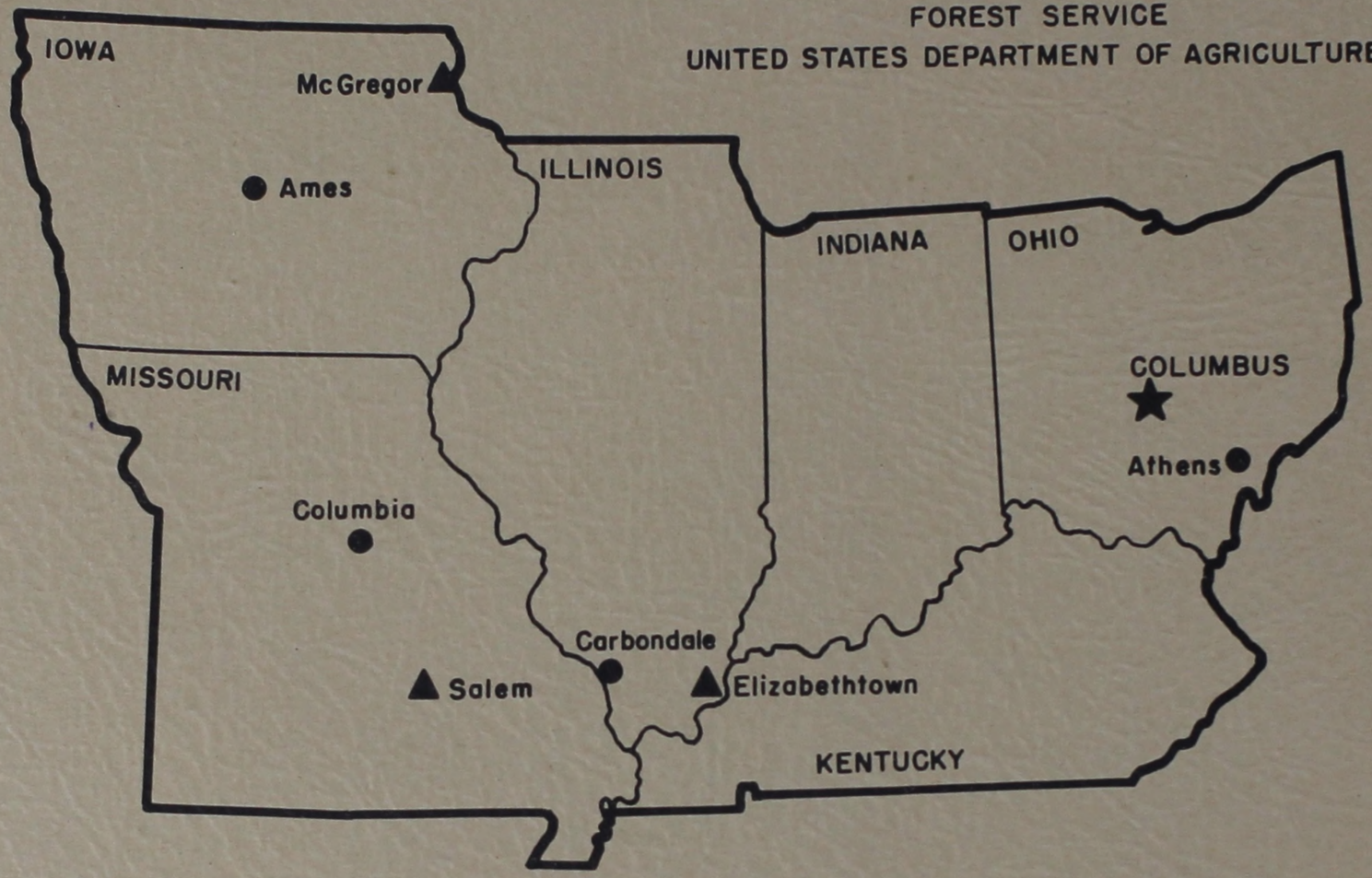
1948 The value of aerial photographs to the forest manager. Proceedings Society of American Foresters' Meeting, 1947: 377-384.

1948 Forest stand-size class keys for photo interpreters. Journal Forestry 46(2): 107-109.

Schnur, G. Luther, and Lane, Richard D.
1948 Log rule comparison, International one-fourth inch, Doyle, and Scribner. Central States Forest Experiment Station. Station Note No. 47.

Winters, Robert K.
1948 The importance of economic considerations in wood-waste utilization research. Proceedings Forest Products Research Society Meeting 1948: 15-21. Paper Trade Journal 127 (3): 22. Journal Forestry 47: 39-45.

TERRITORY SERVED BY THE
CENTRAL STATES FOREST EXPERIMENT STATION
FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE



● RESEARCH CENTERS

▲ EXPERIMENTAL FORESTS

★ CENTRAL STATES HEADQUARTERS